BBC

THE ROCKET TO RETURN HUMANS TO THE MOON

NASA's Space Launch System gets ready for blast off

#201 FEBRUARY 2022

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

2022'S UNMISSABLE

NIGHT SKY MOMENTS

Expert advice to give you the best views of this year's standout events

A DOUBLE DOSE OF COMETS

Track two icy wanderers this month

THE SCIENCE OF THE WEBB TELESCOPE

Discover the astronomical advances the JWST will provide

ISLANDS OF DARKNESS

Stargazing under the dark skies of the Scilly Isles

ENTER A WINNING IMAGE

Astronomy Photographer of the Year 2022 is open!

EXOPLANET ANNIVERSARY

30 years after the first find, where is the science now?

REAL FIELD OF VIEW

What the night sky looks like through the eyepiece

UNISTELLAR

THE UNIVERSE AWAITS

M27
DUMBBELL

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MGN. : 7.5

M51
WHIRLPOOL

DIST. : 23.16 MILLION LY
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Welcome

Get ready for the world's most powerful telescope!

Like most of the astronomical community in the run-up to Christmas 2021 (as we prepared this issue), we were on the edge of our seats here at *Sky at Night Magazine* with a mix of nerves and excitement at the launch of the James Webb Space Telescope (JWST).

Webb is the largest and most complex space telescope ever built, and there is hardly a branch of astronomy that will not benefit from its observations. We look at these on **page 98**, where Ezzy Pearson speaks to the Director of Sciences and Exploration at NASA's Goddard Space Flight Center about the science that the JWST will deliver from its destination in deep space. Then on **page 16**, Chris Lintott and Lewis Dartnell pick out some of the scientific proposals for Webb's time which have caught their eye.

Once launched, Webb will go through around 50 major stages of deployment as it unfurls from the nose cone of its launch rocket. This all takes place over two weeks – during which time this issue should have reached you – as the JWST travels to the Sun–Earth L2 Lagrange point, 1.5 million kilometres away. We wish it well on its voyage!

Our view of the stars holds much to look forward to next year too. On **page 28**, Charlotte Daniels takes a detailed look at some of the most exciting events to come in 2022's night sky. We hope imagers and visual astronomers find the practical advice here helps with planning some great observations of the conjunctions, occultations and oppositions to come – not forgetting the increasing chance of strong auroral displays.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 17 February 2022.

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Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

Online
Visit our website for competitions, astrophoto galleries, observing guides and more

Social media
Follow us on Twitter, Facebook and Instagram for space news, astro images and website updates

Podcasts
Listen to our Radio Astronomy podcasts where the magazine team and guests discuss astro news

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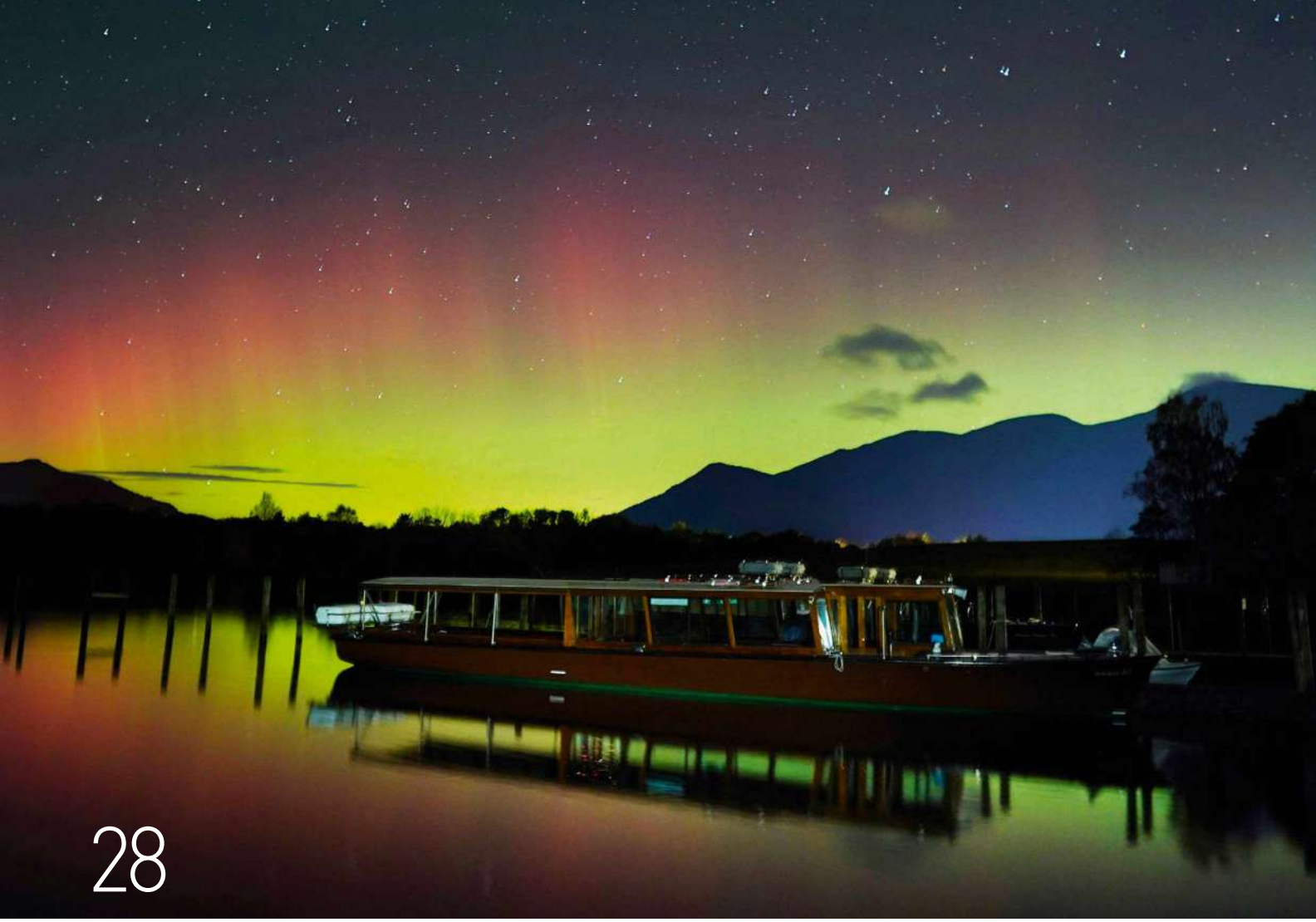

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The Sky Guide

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COVER IMAGE: NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA). THIS PAGE: PA IMAGES/ALAMY STOCK PHOTO, COSMOS, @THESHED_PHOTOSTUDIO, WILL GATER, LÁSZLÓ FRANCSICS, NASA,ESA, BBC

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Charlotte Daniels

Astrophotographer

"There's lots to observe in the night skies in 2022, and it was exciting to look into what's coming up. I'm looking forward to it all now!" **Charlotte points out next year's highlights for visual observing and astro imaging,** page 28

Will Gater

Astronomy journalist

"When starting out in astronomy, it's really useful to have an idea of what celestial objects will look like visually through a telescope." **Will shows how eyepiece views differ from astrophotos,** page 60

Penny Wozniakiewicz

Planetary scientist

"Writing this article on exoplanets was engrossing – I've always found the idea that we can find and even study planets beyond our Solar System amazing" **Penny explores how exoplanets are characterised,** page 72

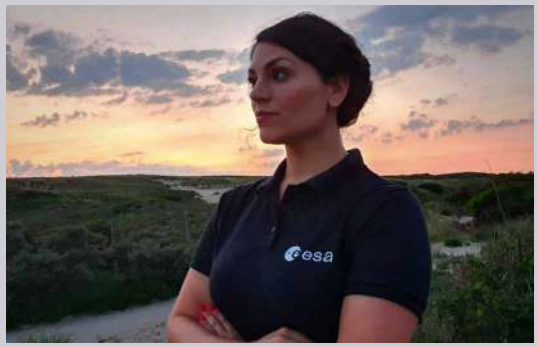
Extra content ONLINE

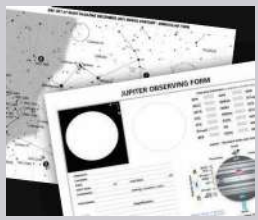
Visit **www.skyatnightmagazine.com/bonus-content/G0ISV6Y/** to access this month's selection of exclusive Bonus Content

FEBRUARY HIGHLIGHTS

Interview: astrobiologist Nicol Caplin

Deep Space Exploration Scientist Dr Nicol Caplin reveals how microorganisms can assist human spaceflight





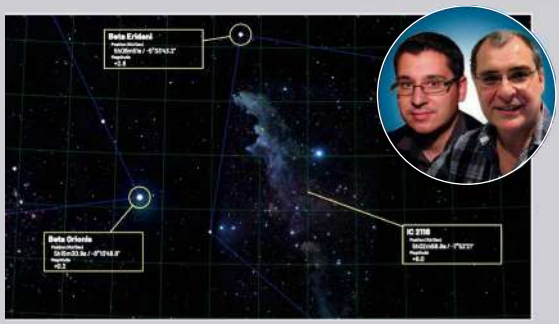
Watch *The Sky at Night: Review of the Year*

In this special episode, Maggie and Chris look back at their favourite moments from filming *The Sky at Night* in 2021.

Plan your observing for the month ahead

Download extra charts to help you observe the planets and take this month's binocular and deep-sky tours.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

IT'S OH SO QUIET...

Now a vision of tranquillity, it's not long since a supernova was spotted in this spiral galaxy

HUBBLE SPACE TELESCOPE, 13 DECEMBER 2021

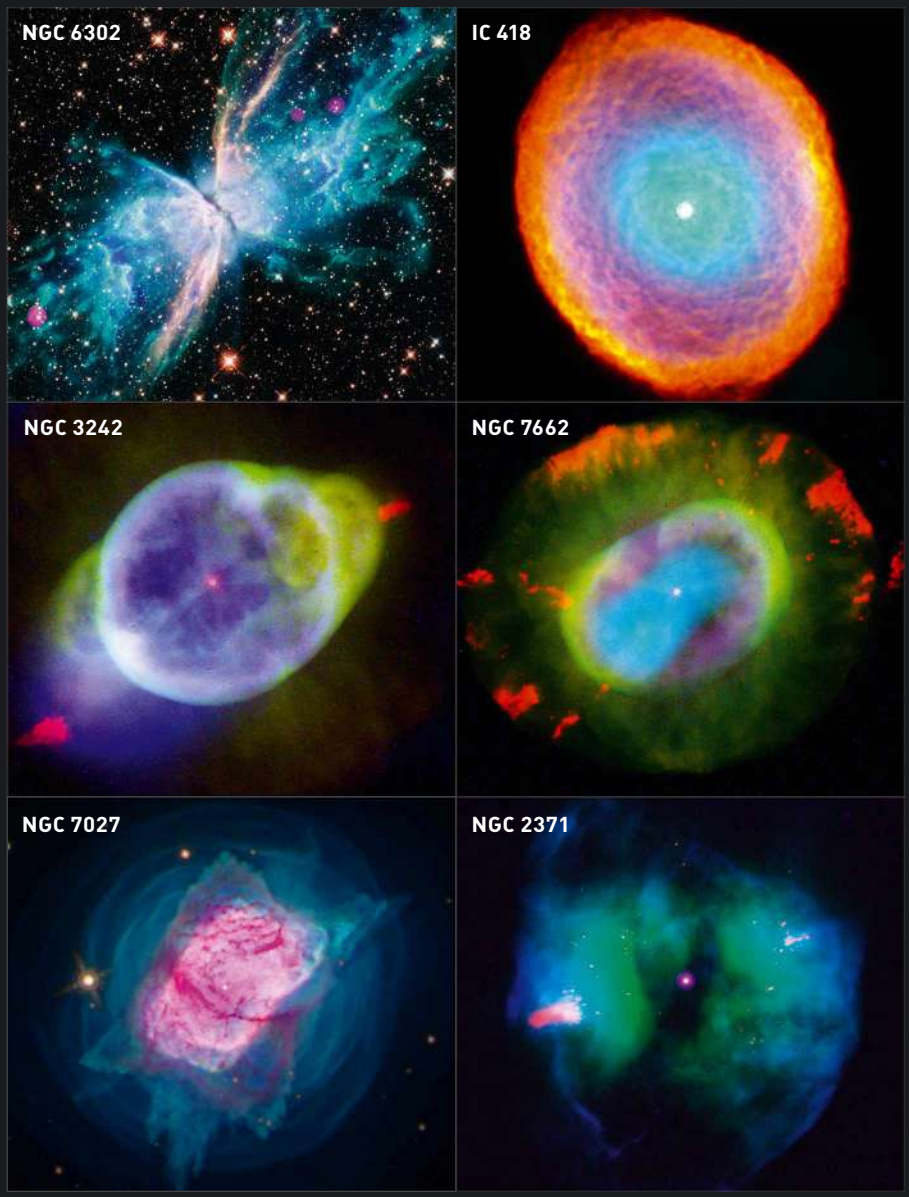
It's a safe bet that at any given moment on any day of the year, an amateur astronomer somewhere is scanning the skies. That's why, even with quite modest scopes, citizen scientists can play a valuable role in catching transient celestial events.

This barred spiral galaxy is NGC 3568 in the Southern Hemisphere constellation of Centaurus, the Centaur. Although all is peaceful in this new image from the Hubble Space Telescope, things were more violent in 2014 when one of its stars went supernova. Like all Type II supernovae, it resulted from the massive star running out of fuel at its core and imploding, causing a rapid contraction followed by an explosive rebound. For a short time, a star that had been just one of the firmament outshone all the others in the galaxy.

Later named SN2014dw, this one was spotted by supernova sleuth Stu Parker and is one of the 194 discovered by Backyard Observatory Supernova Search, a group of New Zealand and Australia-based amateur astronomers.

MORE ONLINE
A gallery of these and more stunning space images

ESA/HUBBLE & NASA, M. SUN



△ Colourful collapses

CHANDRA X-RAY OBSERVATORY/HUBBLE SPACE TELESCOPE, 6 DECEMBER 2021

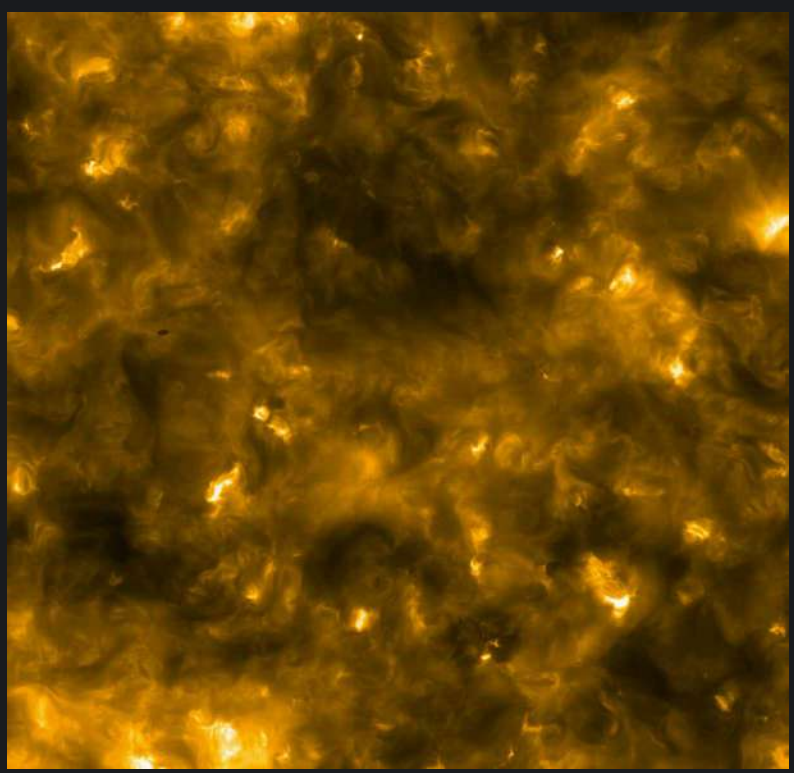
These new combined X-ray and optical images showcase the riotous variety of planetary nebulae. Not planets at all, but giant stars that have exhausted their nuclear fuel, collapsed and then shed their outer layers, each has a hot white dwarf core – a stellar corpse – but myriad eccentric variations in their delicate gas shells. Our Sun will go through the same process several billion years from now.

Hit the gas ▷

HUBBLE SPACE TELESCOPE, 24 NOVEMBER 2021

These fingers reaching up from the inky blackness are luminous clouds within the Running Man Nebula. A Herbig-Haro object called HH 45, the bright multi-coloured shockwaves are the result of high-velocity jets of matter gushing from a newly formed star and slamming into the surrounding molecular gas.

NASA/CXC/RIT/J. KASTNER; OPTICAL: NASA/ESA/AURA/STSCI, NASA/CXC/SAO; OPTICAL: NASA/ESA/AURA/STSCI, NASA/CXC/SAO; OPTICAL: NASA/STSCI/UNIV. WASHINGTON, B.BALICK, NASA/CXC/SAO; OPTICAL: NASA/ESA/AURA/STSCI, NASA/CXC/RIT/J. KASTNER; OPTICAL: NASA/ESA/AURA/STSCI, NASA/CXC/SAO; OPTICAL: NASA/ESA/AURA/STSCI, NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA, NASA/ESA/J. BALLY (UNIVERSITY OF COLORADO AT BOULDER) AND DSS, SOLAR ORBITER/EUI TEAM/ESA & NASA



△ Whipped into shape

MARS RECONNAISSANCE ORBITER, 29 NOVEMBER 2021

Looking not unlike a crusty pie with a slice missing, this is a 1km-wide impact crater on Mars. The northern middle latitudes of the Red Planet are full of craters with these 'aeolian' ripples, undulations around their edges and along their floors carved by the Martian winds.

◁ Within touching distance

SOLAR ORBITER, 14 DECEMBER 2021

Solar Orbiter gives us some sense of what its counterpart the Parker Solar Probe just experienced. This image, capturing 348,000 x 348,000 kilometres of the broiling corona – the Sun's outer atmosphere – was released as Parker made history, flying closer to the Sun than any spacecraft has ever been before, passing through the corona and sampling particles and magnetic fields there.

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

James Webb Space Telescope launches

Hubble successor's perfect start on its month-long 1.5 million km journey

The Christmas Day launch of the James Webb Telescope (inset) promises more detail on the cosmos than ever before

NASA/BILL INGALLS, JAVIER ROMÁN & PAVEL MANCERA PIÑA

A new window is about to open on the Universe after the launch of the James Webb Space Telescope (JWST) on 25 December 2021 at 12:20 UT. The telescope is a 6.5m-wide infrared space observatory that will be able to view the cosmos in precise detail – from the atmospheres of our neighbouring gas giants to galaxies on the edge of the Universe.

Though predominantly a NASA mission, the spacecraft was launched successfully from Spaceport Europe in French Guiana by the European Space Agency, on board an Ariane 5 rocket. At an altitude of 1,400km, the observatory and rocket separated and JWST released its solar panels a few minutes later. The telescope will spend the next 30 days travelling to the second Lagrange point (L2), a gravitational stable region 1.5 million km from Earth.

However, as the telescope was folded up to fit inside the rocket, it has undergone the most complex deployment ever attempted in space, with up to 50 separate stages. The most fraught of these is deploying the sunshield – five layers of Kapton foil, each the size of a tennis court but only 50 micrometres thick – that keeps the telescope cool. The sunshield boom deployed on 1 January, before being pulled tight over several days (with a brief delay to optimise the space observatory's power systems).

The main mirror began deployment on 5 January, with the deployment of the primary mirror's outer petals due a few days later (after this issue went to press).

The JWST is expected to reach L2 on 23 January, where it will spend six months checking systems and calibrating itself, before it begins scientific observations in around six months time. **https://webb.nasa.gov/**

Comment

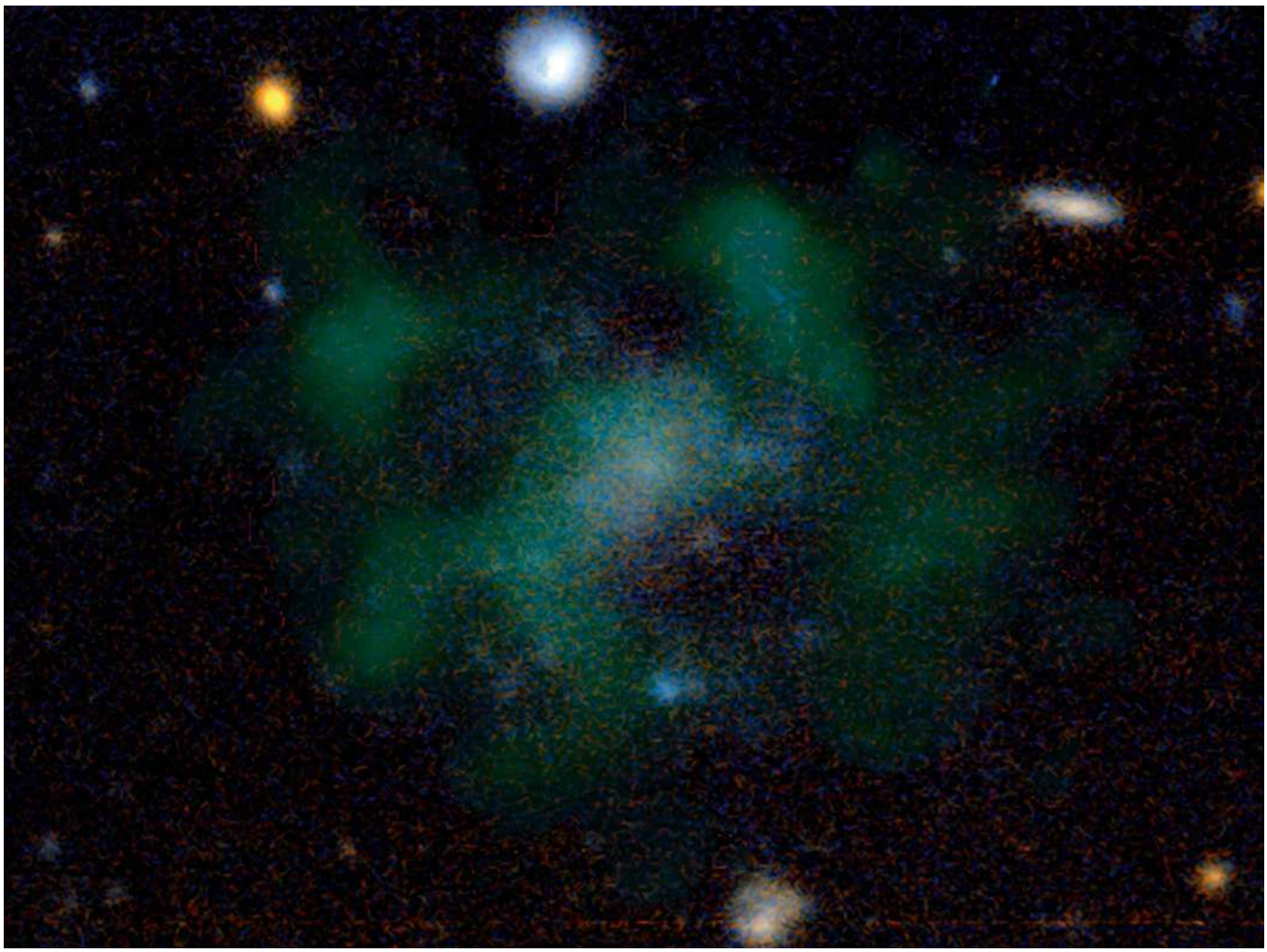
by Chris Lintott

My attempt to take a break from social media over Christmas has been ruined by refreshing the @NASA_Webb and @esa_Webb twitter feeds for updates on the JWST deployment.

The rule is not more than once an hour, but it's hard to be sure you're up to date when looking beyond the official sources often pays off – a legion of astrophotographers is keeping an eye on the precious telescope, reporting a significant increase in brightness as the sunshield deployed.

There's been little drama, with the biggest news being that the JWST team took a day off over New Year. I hope they spent it relaxing; what they're doing really could change our view of the Universe for ever, as well as my Twitter habit!

Chris Lintott co-presents *The Sky at Night*



▲ **Galaxy AGC 114905 has stellar emissions (shown in blue) and clouds of hydrogen gas (shown in green), but no signs of dark matter**

Galaxy confirmed to be free of dark matter

After 40 hours of observations, astronomers have found no trace of the mysterious substance

Our ideas about dark matter could be about to turn on their head, as astronomers have confirmed galaxy AGC 114905 appears to be free of dark matter.

The galaxy is an ultra-diffuse dwarf galaxy, meaning that despite being the same size as the Milky Way, it contains 1,000 times fewer stars. It was one of six galaxies found in 2019, which appeared to be devoid of dark matter – something that our current theories of how galaxies and dark matter works says should be impossible. Even alternate theories such as modified Newtonian dynamics struggle to explain the galaxy's existence.

But such an extraordinary claim requires extraordinary evidence and so a team of astronomers, led by Pavel Mancera Piña from the University of Groningen and ASTRON in the Netherlands, observed the galaxy for 40 hours with the Very Large Telescope. These observations monitored the motion of gas in the galaxy's centre and found that the motions could be completely explained by normal matter in the galaxy, with no need for dark matter.

"This is, of course, what we thought and hoped for because it confirms our previous measurements," says Mancera Piña. "But now the problem remains that the theory predicts that there must be dark matter in AGC 114905, but our observations say there isn't. In fact, the difference between theory and observation is only getting bigger."

One theory is that the galaxy originally had dark matter, but that it was stripped away during an interaction with a larger galaxy, only there are none nearby. Alternately, the angle of the galaxy could be different to what they expect.

"But that angle has to deviate very much from our estimate before there is room for dark matter again," says Tom Oosterloo from ASTRON (The Netherlands Institute for Radio Astronomy), who also took part in the study.

Earlier this year, another team undertook further – though less in-depth – observations of NGC 1052-DF2, another ultra-diffuse dwarf galaxy, which reinforced evidence about its lack of dark matter. Meanwhile, Mancera Piña's team is now studying another galaxy. If these other targets prove to be just as devoid of the mysterious substance, it will strengthen the case for dark matter-free galaxies and prompt some serious reconsideration of our theories about dark matter itself. **www.astron.nl**

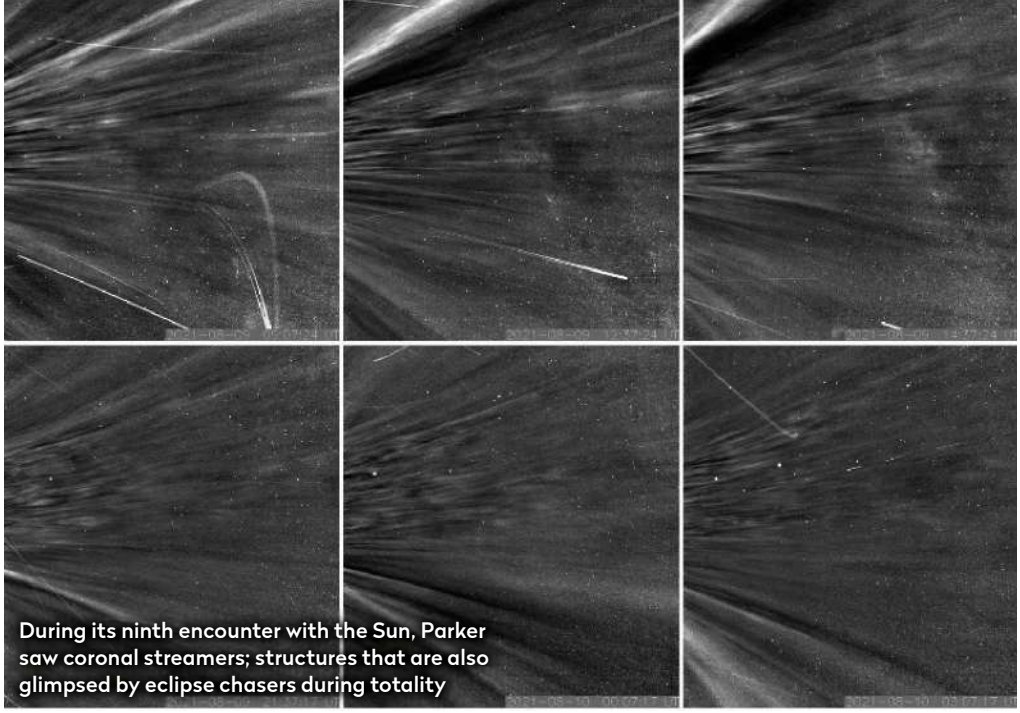
A last gasp for large galaxies

Massive galaxies do not go quietly into the night, it seems, as a new study has found they undergo a last gasp of star formation before shutting down completely.

What causes galaxies to stop birthing new stars has long been an astronomical conundrum. To find the answer, astronomers looked at 3,000 nearby galaxies which host active galactic nuclei (AGN) – galactic cores where the matter swirling around a black hole emits huge amounts of radiation. Rather than the slowly declining rates of star formation they expected, the team instead found formation rates were rising, suggesting AGNs are a rejuvenation phase – a last burst of star birth – before shutting down.

"Galaxies may undergo several rejuvenation episodes until they finally become dormant," says Ignacio Martìn-Navarro from the Institute of Astrophysics of the Canary Islands, who led the study. **www.iac.es/en**

NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA), ESA-M. SABBATINI



During its ninth encounter with the Sun, Parker saw coronal streamers; structures that are also glimpsed by eclipse chasers during totality

Parker touches the Sun's outer atmosphere

The NASA probe reveals the secrets of the corona region

NASA's Parker Solar Probe has made contact with the Sun for the first time, it was confirmed in December. The spacecraft dived in and out of the corona – the outer layer of the Sun's atmosphere – three times in April 2021, though it's taken several months to confirm.

Over three years, Parker has been getting closer to the solar surface. During its eighth close approach, when it was 13 million kilometres out, it sensed a change in its environment.

"We see evidence of being in the corona in magnetic field data, solar wind data and visually in images," says Nour Raouafi, Parker's Project Scientist from the Johns Hopkins Applied Physics Laboratory. As the corona isn't uniform, it flew in and out of the region several times. "We can see the probe flying through coronal structures that can be observed in a total solar eclipse."

Parker will continue to move in closer to the Sun, mapping out the solar atmosphere, before reaching a closest approach distance of around 6 million kilometres in 2025. **parkersolarprobe.jhuapl.edu**

Walking in the Moon's shadows

Thirteen teams from Europe and Canada have competed in the first ESA-ESRIC Space Resources Challenge. The contest sent forth all manner of prototype rovers – from traditional wheeled vehicles to those that scuttle on multiple legs – to explore a simulated lunar surface in Valkenberg, the Netherlands.

The Space Resources Challenge put prototype rovers to the test in a simulated 'Moon Yard'

The challenge pushes space researchers and institutions to develop vehicles capable of exploring the lunar south pole for resources future missions might need. The 'Moon Yard' at Valkenberg is set up to simulate the low-light conditions in the region, including the permanently shadowed craters which could harbour water ice.

During the contest, the rovers had to map out an impact crater, tagging potential resources, while dealing with communications breaks, all within two and half hours. The judges will eventually pick five winners, who will be awarded €375,000 to develop their ideas for the next stage of the challenge in 2022. **www.spaceresourceschallenge.esa.int**

NEWS IN BRIEF

ILLUSTRATION

Bombarding Venus

The asteroids which impacted early Venus were, on average, travelling much faster than those that hit Earth, according to recent simulations. These probably blasted away our sister planet's atmosphere and released volatile gases into the air, potentially explaining the hellish environment of Venus today.

Black hole duet

ESO's Very Large Telescope has discovered the closest pair of supermassive black holes to Earth to date. The two are a mere 89 million lightyears from Earth (the previous record was 470 million), with one weighing in at 154 million solar masses, while the other is just 6.3 million.

Next-Gen asteroid hunting

NASA released Sentry-II, a next generation tool that can accurately and rapidly calculate the impact probability of near-Earth objects (NEOs), in December 2021. The update helps keep pace with the rising number of NEOs being discovered by surveys – around 3,000 every year.

NEWS IN BRIEF

ESA/NASA/NRL/SOLOHI/GUILLERMO STENBORG, NATIONAL ASTRONOMICAL OBSERVATORY, NASA/JPL-CALTECH

Leonard brightens

Comet C/2021 A1 Leonard surged in brightness on 20 December 2021, jumping from mag. +5.0 to mag. +2.0. The brightening could be a sign the comet will break up on its approach to perihelion on 3 January 2022, though at the time of writing the comet was still whole.

Water stored in clay?

Mars's missing water could be locked up in a clay mineral called smectite, which traps water in its structure. A recent batch of lab experiments found the mineral could form stable beds up to 30km thick, much deeper than previously thought and capable of holding a huge amount of water.

ALMA due for an upgrade

The Atacama Large Millimeter/submillimeter Array (ALMA) is getting a multi-million dollar upgrade to its 1.3mm receiver – its most scientifically productive. This will increase the instrument's wavelength coverage and sensitivity. A prototype of the receiver is expected by 2026.

BULLETIN

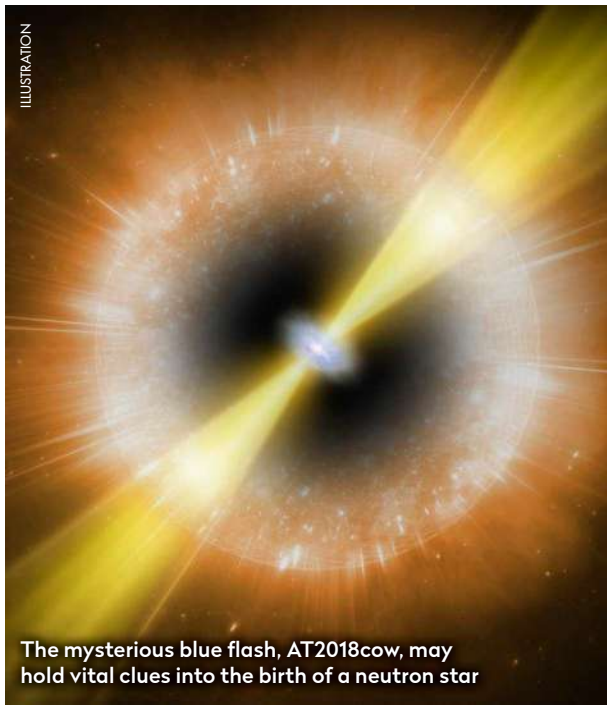
Witnessing a neutron star's birth

Was the blue outburst the creation of a superdense star?

Astronomers may have caught the moment when a supernova became a neutron star, perhaps even a black hole.

In June 2018, telescopes around the world homed in on a flash of blue light 100 times brighter than a supernova, called AT2018cow (or 'The Cow' for short), coming from a galaxy 200 million lightyears away. Follow-up observations found the object flashed out X-rays every 4.4 milliseconds, which suggests an object 1,000km-wide and makes a neutron star or black hole the most likely cause. It's thought one of these formed in a collapsing star, then devoured the material around it to generate an energy burst.

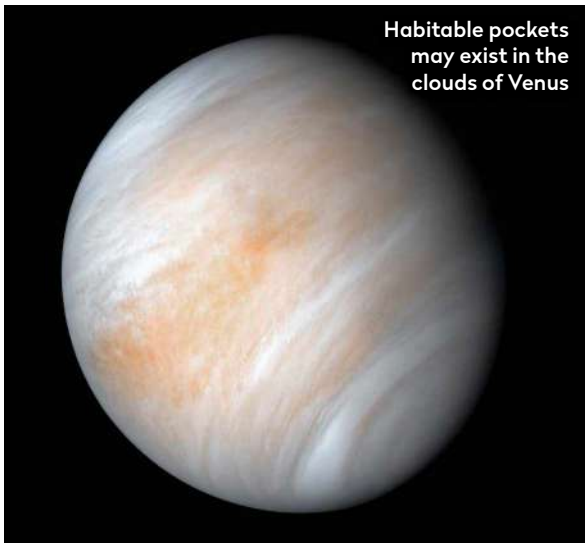
"We have likely discovered the birth of a compact object in a supernova," says lead author Dheeraj Pasham, from the Massachusetts Institute of Technology. "This happens in normal supernovae, but we haven't seen it before because it's such a messy process. We think this new evidence opens possibilities for finding baby black holes or baby neutron stars." **www.mit.edu**



ILLUSTRATION

The mysterious blue flash, AT2018cow, may hold vital clues into the birth of a neutron star

Life could neutralise Venus's acidic clouds



Habitable pockets may exist in the clouds of Venus

The caustic clouds of the planet Venus might seem a very unlikely place to look for life, but a new study has shown it is at least theoretically possible for microbial life to create habitable pockets there.

No life we know of would be able to live on Venus, so the team behind the study instead looked at ways life could neutralise the sulphuric acid in the clouds. They started by studied one of the most inexplicable components of Venus's atmosphere – ammonia.

"Ammonia shouldn't be on Venus," says Sara Seager from the Massachusetts Institute of Technology, who took part in the study. "It has hydrogen attached to it, and there's little hydrogen around. Any gas that doesn't belong in the context of its environment is suspicious for being made by life."

The study revealed that whatever the source of this ammonia, its presence would create a cascade of chemical reactions that could neutralise the acid, and even explain other anomalies, such as small amounts of oxygen and oddly-shaped droplets, which have been observed before in Venus's clouds. **www.mit.edu**

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And for so many survivors the road to recovery is still long and desperately lonely. If you or someone you love has been affected by stroke – you'll know just what that means.

But it doesn't have to be like this. You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries and every single stroke survivor has the best care, rehabilitation and support network possible, to help them rebuild their lives.

Big or small, every legacy gift left to the Stroke Association will make a difference to stroke survivors and their families.

Find out how by calling 020 7566 1505
or email legacy@stroke.org.uk
or visit stroke.org.uk/legacy

Rebuilding lives after stroke

The Stroke Association is registered as a charity in England and Wales (No 211015) and in Scotland (SC037789).
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Stroke Association

Our experts examine the hottest new research

CUTTING EDGE

JAMES WEBB SPACE TELESCOPE SPECIAL

One proposal would use the JWST to image gas giants around Alpha Centauri A

ILLUSTRATION

A whole new world view

The JWST will open up new windows to explore exoplanets and their atmospheres

All being well, the James Webb Space Telescope (JWST) which launched on 25 December, has successfully reached its target at L2 (Lagrange point 2), on the far side of Earth to the Sun, where the gravity of the two large bodies and the centrifugal force balance each other. After a six-month testing process it will begin scientific observations, probably in June. The global astronomical community will get its first chance to use this new platform through the Cycle 1 General Observers (GO) program (see **bit.ly/3J7v6AE** for more details). This project gives astronomers a chance to use some of the 6,000 hours on offer for their research. Here are three of their proposals...

Charles A Beichman at the Jet Propulsion Laboratory (JPL) and his team will use JWST's coronagraph to attempt to image any small gas giant planets (down to half of Jupiter's radius) around our closest Sun-like star, Alpha Centauri A, in their proposal *Searching Our Closest Stellar Neighbor for Planets and Zodiacal Emission*. They'll focus their search within three Astronomical Units of the star, where calculations predict a region of orbital stability, safe from the gravitational disruption of its binary twin Alpha Centauri B. They will also try to see out to the interplanetary dust, which in our Solar System produces the zodiacal light. The team admits this is a high-risk attempt, but the chance of imaging a planet around our closest stellar neighbour is thrilling.

Meanwhile, in the proposal *Tell Me How I'm Supposed To Breathe With No Air: Measuring the Prevalence and Diversity of M-Dwarf Planet Atmospheres*, Kevin Stevenson at the Johns Hopkins University Applied Physics Laboratory and his team will observe nine small, terrestrial planets orbiting the nearest M-class red dwarf stars. They will be looking for the infrared spectral signatures of carbon dioxide and methane gases, and therefore whether this category of worlds are able to cling on to an atmosphere. It's a key question about the potential of habitability for life – M-class dwarfs are the most numerous kind of star in the Galaxy and their planets offer the only chance we'll have in the next decade to measure their spectrum. This proposal illustrates the strength of a good name – taken from song lyrics by Jordin Sparks, the 2007 American Idol winner!

'Super-puff' puzzle

In the proposal *Unveiling the Nature of the Impossible Planets*, Peter Gao at the University of California, Santa Cruz, and his team (including members from the University of Oxford) plan to study a mysterious kind of exoplanet known as a 'super-puff'. This type of planet is relatively low-mass (less than Neptune), but seems to have a huge radius – its atmosphere apparently expanded out by the heat of its star. Such a planet ought to have suffered catastrophic atmospheric loss, which makes its existence a mystery. One proposed solution is that it only appears to be much larger than it actually is because it is enshrouded in a high-altitude haze layer.

Gao has been awarded 12 hours of observing time to check this hypothesis, using JWST's near-infrared spectrometer to look for a chemical composition that would indicate a haze in the 'super-puff' planet Kepler-51b. This is one of three super-puff planets orbiting the same star – all Jupiter-sized, but with masses only a few times that of Earth.

Such a planet ought to have suffered catastrophic atmospheric loss, which makes its existence something of a mystery

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

DOTTED ZEBRA/ALAMY STOCK PHOTO, NASA/ESA/G. ILLINGWORTH/D. MAGEE AND P. OESCH/UNIVERSITY OF CALIFORNIA/SANTA CRUZ/R. BOUWENS/LEIDEN UNIVERSITY AND THE HUDF09 TEAM

Galaxies near and far

From our cosmic neighbours to the deepest depths, the JWST will expand our galactic horizons

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

The most important science that the James Webb Telescope (JWST) will do has not been thought of yet. That might sound strange for a project decades in the planning, but every time we open a new window on the Universe we find things we didn't expect, and new uses for telescopes not dreamed of while they were being built.

Take the most famous images produced by Hubble, the 'Deep Fields', the results of staring hard at an apparently anodyne patch of sky to reveal thousands of distant galaxies. Not part of the original plan, this type of observation is now so important that one of the largest projects for JWST in its first year is a 121 hour-long observation of the same patch of sky.

The NGDEEP (Next Generation Deep Extragalactic Exploratory Public) proposal adds infrared imaging – JWST's speciality – to the optical and ultraviolet observations we already have from Hubble. It's hoped that observations in infrared will let the new telescope see further and deeper, catching the era when the first galaxies are assembling. The larger collecting area provided by JWST's 6.5m mirror (which dwarfs Hubble's) will let us see lower mass galaxies. We may even see the sites where the first black holes are just forming.

Every time we open a new window on the Universe we find... new uses for telescopes not dreamed of while they were being built

Galactic insight

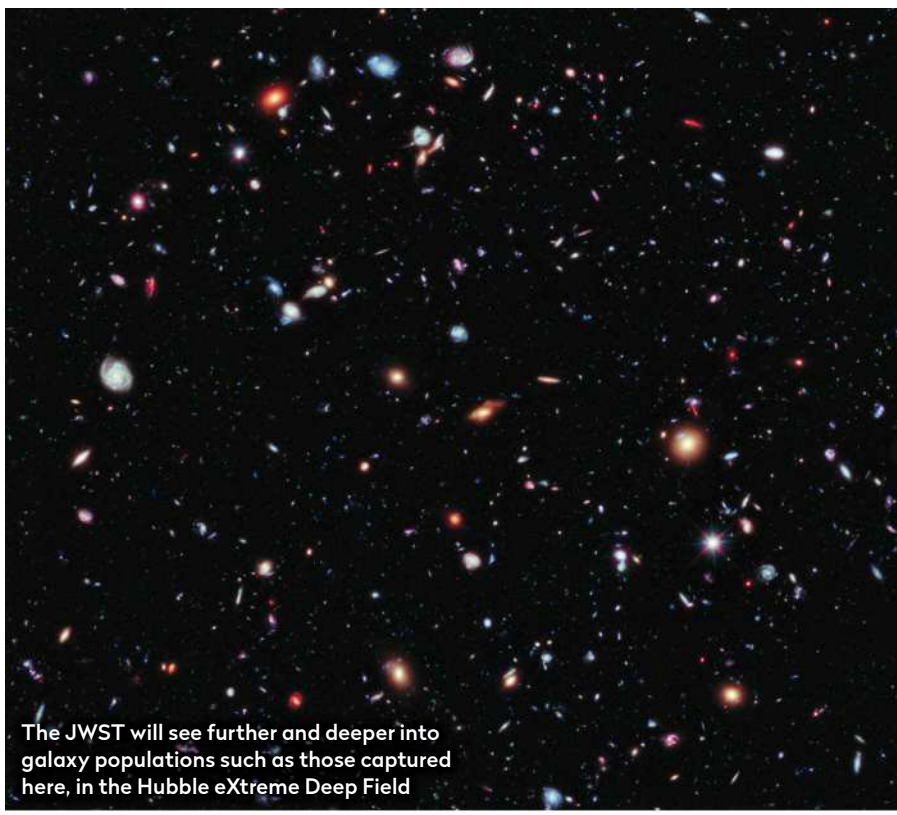
There is plenty more for galaxy enthusiasts to get excited about in the first tranche of observations. Take the case of the PRIMER (Public Release IMaging for Extragalactic Research) survey, which covers the area of the sky previously observed by major Hubble space telescope surveys. As for other proposals, adding infrared images will tell us much more about galaxies we already know. But the real prize will be the 80,000 or so new systems which haven't ever been detected. This population shows that over most of the Universe's history, JWST will be revealing the bulk of the galaxy population, showing us normal systems, rather than the spectacular starbursts and massive systems that shine brightly enough to be in our catalogues already.

Moving closer to home, a proposal most likely to create spectacular images is one led by Janice Lee, which will compile images of 19 nearby galaxies. Together with ground-based telescopes like ALMA, for the first time, we should be able to see exactly where star formation is happening in these systems.

In the Milky Way itself, there are proposals to target known protostars. In these investigations, it will be JWST's ability to use a type of instrument called an IFU (integral field unit), which takes a picture and multiple spectra at the same time. We know that star formation is a complicated process, as winds and activity from the newly formed star interact with the protoplanetary disc and still collapsing cloud. So these observations will help us understand what's going on inside stellar nurseries.

From distant galaxies to the newest stars in our neighbourhood, there is a lot to look forward to. But don't forget the power of surprise. The majority of JWST observations, which will feature in future pages of this magazine, haven't even been dreamt of yet.

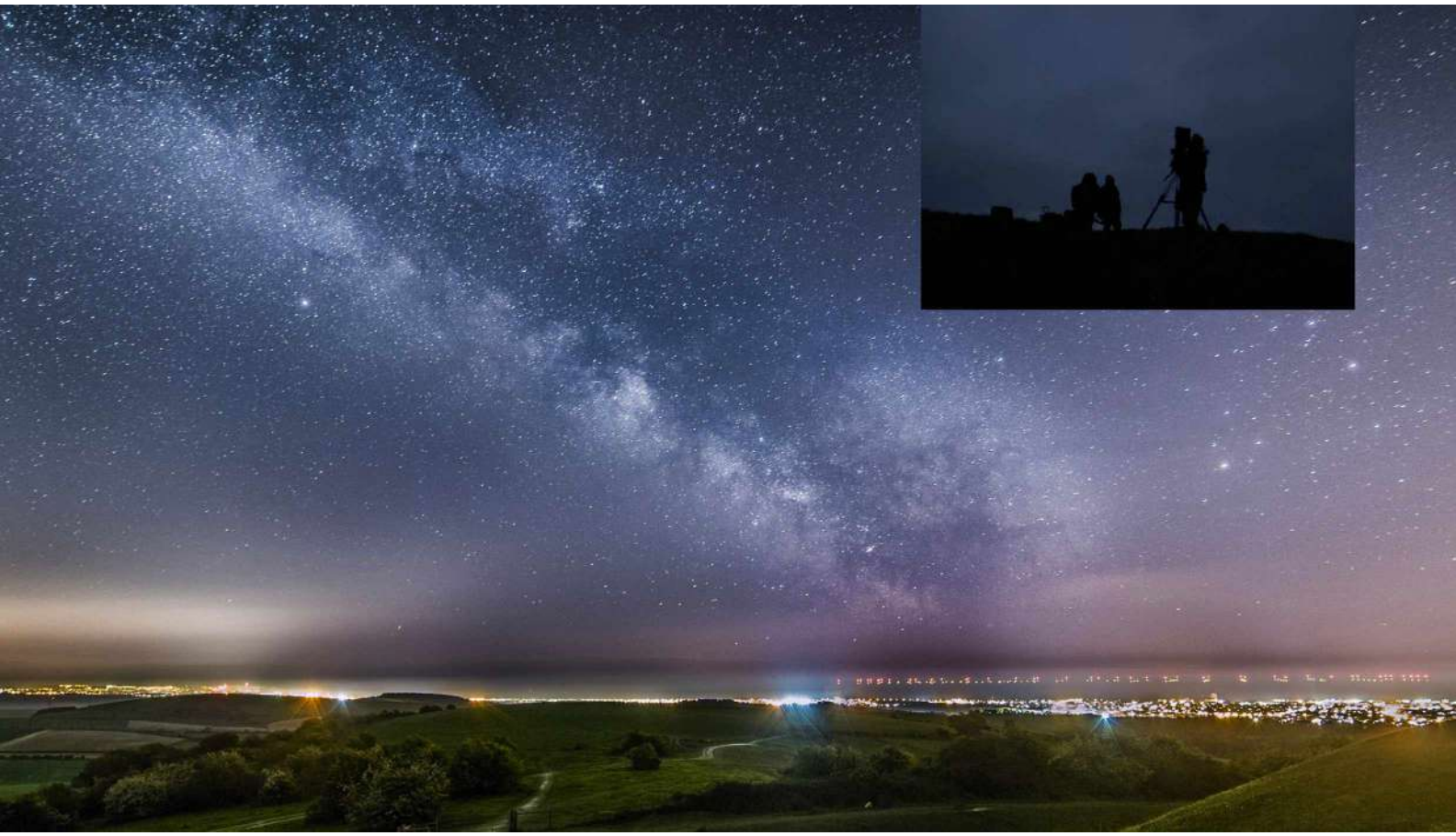
To read more on the Cycle 1 Go proposals from both these *Cutting Edge* sections, see **www.stsci.edu/jwst/science-execution/approved-programs/cycle-1-go**



The JWST will see further and deeper into galaxy populations such as those captured here, in the Hubble eXtreme Deep Field

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



With multiple locations and interviewees, there was plenty to organise for January's *Sky at Night*, and **Carisse Perks** made it all run smoothly

Despite not being what anyone would call an 'outdoors person', in late November 2021 I found myself shivering on top of a very windy hill in Hampshire waiting for the Sun to set. After all, what's a *Sky at Night* episode about dark skies without filming under some?

I have always loved TV, so late one day in March 2017, while thinking long and hard about what I wanted to do with my life, I released *that* was it. I did some research into the different roles and routes into the industry, and thought that with my background in admin, the production management route was the right one for me. I am now the Production Coordinator on *The Sky At Night*. Whenever anyone asks me what it involves, I usually say, "It's mostly booking trains." But in reality it is a lot more than that.

We usually film one episode per month, around two and half weeks before the episode is due to air, as each episode takes two weeks to edit. This wasn't possible for the January episode, as that would have meant filming over Christmas and New Year – and trying to get locations, interviewees, editors, film crew and presenters all available at the same time is hard enough at the best of moments! So we filmed this in November, just before our December episode.

Multiple locations

I set up filming at our three main locations. As well as the South Downs National Park with presenter Pete Lawrence, we also filmed at the Van Gogh 'Immersive Experience' in East London, with Chris Lintott and Maggie Aderin-Pocock chatting about how the night sky has changed over the years since Van Gogh painted his famous *Starry Night*. Lastly, we recorded at Television Centre in West London with the Baker Street Irregular Astronomers telling Chris how they do astronomy in Central London with its high levels of

▲ On location: Carisse Perks, *The Sky At Night*'s Production Coordinator, sets up multiple filming locations for each episode. Recently the team visited the South Downs National Park (above), for a night shoot (inset) involving a little too much cloud

NEIL JONES, PETER LEONARD, MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, BBC/NEIL HARVEY

Carisse Perks is the Production Coordinator for *The Sky at Night*

light-pollutiion. I'm the main point of contact for any location, and so I make sure we have the right permissions, negotiate access times and make sure that the location is aware of how many of us are turning up, which can be between two and ten people.

While it is not the norm for Production Coordinators to go out on location, I try and go whenever I can, and I have been on near-enough every shoot of this series. It's invaluable when it comes to dealing with post-production paperwork and talking about the episodes with each of the team. Every episode is different, but I am generally on hand for all important lunch and coffee runs, as well as helping to carry some of the vast amount of kit.

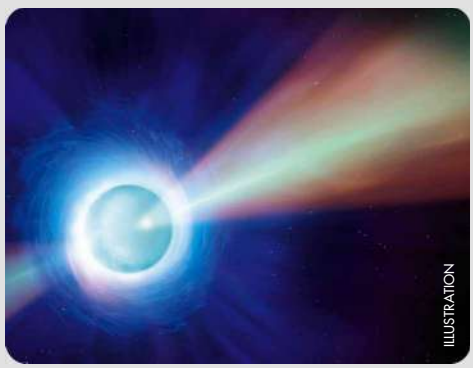
It's also my job to keep an eye on the budget, and make sure we don't overspend. Thankfully, there is a lot of goodwill towards our show, and most people are happy to negotiate with me!

And so back to that hilltop in November. Yes, it was cold and a little muddy. And yes, we had to lug a huge amount of film equipment up a hill. And yes, it was still cloudy so we couldn't see the stars. But, in the dark, among the sheep, I couldn't help feeling proud to be a small part of the 818th episode of this long-running show, in Moore's Reserve – a dark-sky site named for our most famous presenter.

Looking back: The Sky at Night

18 February 1991

In the February 1991 episode of *The Sky at Night* Patrick spoke with Andrew Lyne, an astronomer from Jodrell Bank near Manchester. They discussed millisecond pulsars, which flash radio waves hundreds of times a second with such precise timing they're often referred to as 'the fastest clocks in the Universe'. The Lovell Telescope at Jodrell Bank has observed pulsars since they were first discovered over 50 years ago, and today monitors over 800 radio pulsars.



▲ **Because the rate of a pulsar's spin is so precise they are used as cosmic clocks**

A pulsar is the rapidly rotating remains of a dead star, normally a neutron star though they can be white dwarfs. These stellar corpses are highly magnetised and emit intense beams of electromagnetic radiation from their poles. As the stars rotate, the beams sweep across space. On Earth, we see them as a faint point of light blinking on and off, visible only when the beam passes over. The rate of a pulsar's spin is precise, hence their use as cosmic clocks.

The first pulsar to be discovered in 1967 pulsed once every 1.33 seconds, which was why astronomers were shocked in 1986 when the Lovell Telescope detected a pulsar flashing once every 1.55 milliseconds. It was the fastest pulsar yet seen, and remained so until 2005, when a pulsar with a pulse of 1.39 milliseconds was discovered.

Universe

The Sky at Night is taking a break in February and March, and will return in April for more adventures in astronomy and spaceflight. In the meantime, you can still catch up with Professor Brian Cox's latest series *Universe*, which is available to watch on the BBC iPlayer. In this five-part series, Professor Cox takes a trip across space and time to reveal the chaotic and often beautiful moments that irrevocably altered the evolution of the cosmos.

▸ Watch via **bbc.co.uk/iplayer**

▲ **Brian Cox's latest series explores the events that shaped our Universe**

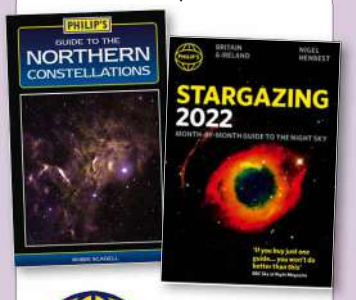
Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles



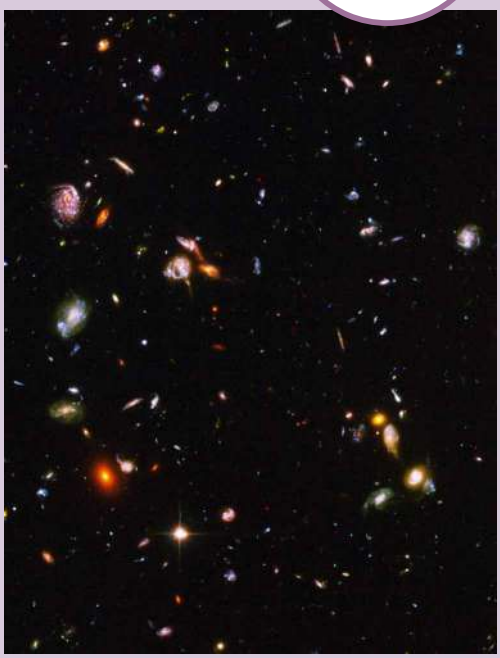
The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2022* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Ancient light

Recently, I have been listening to a number of Professor Brian Cox's fascinating lectures on YouTube. He mentioned that light travels in straight lines and I have a question about that. Does this mean that in the Hubble pictures of multiple galaxies – where the farthest object is 13 billion lightyears away – the 13 billion-year-old light has not been blocked or absorbed by any other object? Are we only observing the light that got through, and could there be more that we do not see – or is this where gravitational lensing comes into play?
David Hewitt, Leigh on Sea

That's correct, David, the light we see from 13 billion years ago is indeed only what manages to get through the dust and gas that fills the cosmos. Lensing is a bit different, though, and is where distant light is 'bent' around massive objects closer to us and not absorbed by it, sometimes making the light dimmer, sometimes brighter **– *Ed.***



▲ A small part of the Hubble Ultra Deep Field image, which captured nearly 10,000 galaxies including small, red examples 13 billion years old

NASA/ESA AND S. BECKWITH (STSCI) AND THE HUDF TEAM

Tweet

Andrew Morl
@AndrewMorl • Dec 14
There was normal cloud for the peak of the Geminids, but gaps in the cloud gave us views of the Moon through the 8-inch Dobsonian. The picture is straight off the phone, not edited. @GrassholmeObser @ThisisDurham @ThePhotoHour @skyatnightmag #moonshots

Great ball of fire?

At around 5pm on 23 November I was running with friends between classes at the Southend Campus of Essex University, when we suddenly all noticed what looked like a fireball falling in front of us in the sky. Fortunately, I was lucky to have my phone in my hands and I took a quick picture (above). I have no idea how long the meteor's tail was because it wasn't that close, but I think it was between 50 and 100 metres long. The trail also smoked a little and lingered for about 30 to 40 seconds after the fireball had vanished. When I took the photo, the meteor was falling practically vertically and was in a northwest direction.

I didn't hear any particular noise or a sonic boom coming from the fireball; we all just noticed it in front of us as it was very bright.
Kristina Valeri, Southend on Sea

Well done on being vigilant, Kristina! But this looks rather like an aircraft contrail catching the winter evening sunlight: when they're illuminated like that it's easy to mistake them for a meteor fireball. A fireball as spectacular and close as the object in your photo is likely to have made a sonic boom. One useful place where you can check up on potential fireballs is the UK Meteor Network, and its Fireball section (**ukmeteornetwork.co.uk/fireballs**). Keep looking up! **– *Ed.***

Tweet

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Grid No. 1... #Astrophotography #milkyway #astro #nightsky @BBCStargazing @skyatnightmag @practphoto @UKNikon @NikonEurope @Adobe

New Big Bang?

I'm sure Professor Brian Cox said on his TV programme, *Universe*, that 'far away' galaxies were racing away from us and Andromeda, our nearest galaxy, over 2.5 million lightyears away, is racing towards us. Can I ask why the Milky Way isn't racing in the same direction as Andromeda? If the Universe is supposed to be expanding, how can galaxies be charging together?

I always understood that we were peering further and further back in time but haven't been able to see as far back as the Big Bang yet, but if the Andromeda Galaxy is charging towards us while distant galaxies are charging away from us, surely the Big Bang happened somewhere between Andromeda and the outer galaxies? One imagines that if galaxies millions of lightyears apart can come together, the expanding Universe is at some point going to stop, contract and end up in one more Big Bang!
Kind regards, Peter Haste, via email

Because of the way galaxies formed, they are clumped together in groups. Even though these groups are all moving away from each other as the Universe expands, inside the groups they're close enough to be affected by each other's ▸

ON FACEBOOK

WE ASKED: What are you most looking forward to in 2022?

Harold Siddons The lunar occultation of Mars in December!

Jim Hendrickson Getting clouded out of another lunar eclipse on 15 May.

Keith Mountjoy A partial solar eclipse, oh, and a clear sky!

Steve Roach To seeing if Comet 15P/Finlay is going to give parental guidance to the Delta Cancrids.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I have a pair of Vixen BT 80mm binoculars and observe from a moderately light-polluted site. Are there any eyepieces or filters that would help improve my views?

ANDREW WELLS

▲ **Vixen SLV Lanthanum eyepieces of 12mm and 25mm focal length**

The Vixen BT-80 binoculars have an effective focal length of 900mm achieved by the use of a built-in teleconverter within the 500mm-long optical tube, and they use two Amici prisms to produce a correct orientation image with a 45° viewing angle for 1.25-inch eyepieces. To achieve the best views through these binoculars, keep the magnification to below 85x, which means selecting eyepieces with focal lengths down to about 11mm at the shortest. There's a good selection of eyepieces that would complement the 36mm eyepieces that shipped with this instrument. These include: Vixen SLV Lanthanums (12mm and 25mm); Baader Hyperions (13mm and 24mm); or BST StarGuiders (12mm and 25mm).

Observations of nebulae under your Bortle class 4 skies would benefit from the use of OIII (Oxygen) eyepiece filters like those made by Astronomik or Explore Scientific. For more general observations, a UHC (Ultra High Contast) filter from either of these companies would also be worth considering.

Steve's top tip

What is backfocus?

Backfocus describes the distance from the end of the eyepiece drawtube to the focal plane of a telescope. It is important to ensure that the focuser has sufficient travel both inwards and outwards to achieve focus with either an eyepiece or a camera.

Finding focus with eyepieces is normally straightforward, but the use of a camera can make it difficult to achieve, especially with Newtonian reflectors that often have insufficient inward focuser travel. Insufficient inwards travel is difficult to resolve without moving the primary mirror or inserting a Barlow lens in the optical path. When it comes to a refractor, an extension tube will easily resolve any issue of insufficient outwards travel.

Steve Richards is a keen astro imager and an astronomy equipment expert

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▸ gravitational pull, causing them to jostle about and sometimes collide. ***– Ed.***

Creating squares

There have been some exciting developments with the RAS (Royal Astronomical Society) Bicentennial Quilt this year. The side showing the orbital paths of the Solar System is now completed, but the Sun and planets still require a skilled embroiderer's hand; plus a number of squares have been joined together for the patchwork side.

Also, I've almost finished populating the online image gallery with all the squares for the patchwork side of the quilt (**https://ras.ac.uk/ras-bicentennial-quilt-100-patchwork-squares**). With any luck we will be able to host some in-person stitching sessions in the RAS building next year.
Annie Hogan, Royal Astronomical Society, Piccadilly, London

▲ **The RAS Bicentennial Quilt takes shape**

Instagram

daydreamastro
• 10 December

The Rosette Nebula, as captured with a SkyWatcher Evostar ED80 telescope, HEQ5 pro mount, ZWO294 OSC camera, L-eNhance Optolong filter, using 14x 10min subs, with a total integration of 2 hours and 20 minutes, and processed in Photoshop.

CORRECTION

• Nikos Charalambidis wrote to point out that in the main text on page 46 of the January issue ('Sky Guide', Big Three, Quadrantid Meteors), for the name of the stars in the Plough asterism, the Greek letter zeta should have been 'ζ', not 'ξ', which is the Greek letter xi.

SOCIETY IN FOCUS

The **Eddington Astronomical Society of Kendal** (EAS) was formed in 2004 by local author and astronomer Stuart Atkinson to promote and celebrate the transit of Venus. EAS is named after Sir Arthur Eddington, one of the founders of modern astrophysics, who was born in the Cumbrian town of Kendal.

The Society meets each month and hosts guest speakers at meetings that cover a wide range of topics. EAS also holds public 'Moonwatches' and outreach events, particularly when there is something significant happening. We set up telescopes and encourage the public and passers-by to look through them: in many instances it's their first view.

Despite COVID, the EAS has met regularly and has had some fascinating talks via Zoom, and our monthly newsletters have proved to be popular. We are currently experimenting with hybrid meetings, where members attend either in person or via Zoom.

▲ **The EAS during a public Sunwatch at the Brewery Arts Centre in Kendal**

Our most recent planned Moonwatch – our first since the pandemic – was due to take place in November 2021 along with Friends of the Lake District. Sadly, the weather was not in our favour, but we hope to host another one soon!

If you are in the area and want to join in, why not get in touch. Our programme and blog are on our website (address below).
Ian Bradley, chairperson; David Glass, meetings coordinator
▸ eas-online.org.uk

We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

TONY MARSH, LOOM GRAPHICS, JOHN MACDONALD

Live North York Moors and Yorkshire Dales Dark Skies Festival

Various venues, 18 February–6 March

Enjoy the star-spangled skies of two International Dark Sky Reserves, with expert talks, art exhibitions, stargazing safaris, night-time walks and rocket building among the festival fortnight's highlights. Charges apply to some events. **darkskiesnationalparks.org.uk**

Live Delamont Country Park observing evening

County Down, Northern Ireland, 4 February

All ages and levels of ability are welcome to this monthly public observing session hosted by the Irish Astronomical Association. Sessions are planned for the first Friday of each month, but may be rescheduled in bad weather. For updates see **facebook.com/groups/irishastro**

Online Stars and constellations

5 February–5 March, 11am

Join Dr Adrian Jannetta of Northumberland Astronomical Society for an introductory course focusing on Orion, Ursa Major, Gemini, Taurus and Virgo. Held via Zoom over five weeks, the course costs £15. Book at **bit.ly/3yh0kjB**

Live Extraterrestrial life

Village Hall, Norton sub Hamdon, Somerset, 16 February, 7:30pm

Crewkerne & District Astronomical Society hosts James Fradgley FRAS as he ponders the possibility of complex life beyond Earth, in 'Life in the Universe: Are the Aliens Out There?'. Visitors welcome (first meeting free). **www.cadas.net**

Online The Red Sun

18 February, 7:30pm

Lyn Smith, Director of the BAA's Solar Section, leads a tour through the chromosphere, looking at prominences, filaments and flairs. Watch on the Astronomical Society of Edinburgh's YouTube channel at **bit.ly/30gkCNK**

Online Discover Exoplanets

24 February, 10am

Aimed at teachers and learners aged 16–19, this talk by Kate Isaak, Project Scientist for ESA's CHEOPS mission, introduces the techniques used to find and study exoplanets. Free. **bit.ly/31CvS7T**

Live Kenley observatory open evenings

Hayes Lane, Kenley, Croydon, Saturdays

Croydon Astronomical Society welcomes the public to its Norman Fisher Observatory every Saturday evening for a free observing session, depending on the weather. See **bit.ly/3pJr4W9** for details.

PICK OF THE MONTH

▲ Scotland's Astronomer Royal Catherine Heymans tops the festival bill of astronomy talks

Live & Online Hebridean Dark Skies Festival

Lewis, Outer Hebrides, 11–25 February

This two-week festival under some of the UK's darkest skies returns for a fourth time with a lively mix of entertainment and astronomy. As well as stargazing, a host of indoor events will be happening at community venues across the island and online too, from astronomy workshops and talks, including one with Scotland's new Astronomer Royal Catherine Heymans, to music, comedy, theatre, films, guided night walks and even a night swim for the very brave. For tickets, call 01851 708480 or visit **www.lanntair.com**

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FIELD OF VIEW

What's on the space menu today?

Jonathan Powell looks at the challenges of getting a balanced diet in space

Dining in space has certainly moved on from high protein food and drink, stuffed toothpaste-style into aluminium tubes, that was the fare for Yuri Gagarin, the first human to eat in space onboard Vostok 1 in 1961. His meal comprised a tube of beef and liver pâté, and chocolate sauce for pudding.

NASA's Mercury astronauts of the late 1950s and early 1960s fared little better. They found their space diet of bite-sized flavoured cubes and tubes of semi-liquids wholly unappetising, with the added trouble of not being able to easily rehydrate their freeze-dried foods.

More palatable food was on offer for NASA's Gemini and Apollo missions from 1965 to 1975. By then, hot water was available aboard spacecraft, revolutionising the rehydration process. Even chicken and vegetables were on the 'specials' menu, followed by butterscotch pudding. However, the crew of Gemini 3 still smuggled a corned-beef sandwich onto their orbital flight – and were duly reprimanded by NASA on their return.

Buzz Aldrin's holy communion on the Moon – with wine and bread blessed two weeks prior to the mission, and cleared for use by NASA's director of flight crew operations – was the first instance of food and drink consumed on the lunar surface. Aldrin and Neil Armstrong's first meal together included bacon (in squares), sugar cookie cubes and coffee. Then, after venturing out on a moonwalk, they returned for cocktail sausages and fruit punch.

By the early 1970s and the Skylab space station era, astronauts were cooking on gas (not literally). The advent of the onboard fridge freezer meant an extended menu, boasting 70-plus food items, including shrimp cocktail, Lobster Newberg, ice cream, fresh bread and processed meats. Additionally, eating arrangements became more civilised with a table and chairs bolted to the floor.

NASA almost included alcohol, in the form of fortified wine, on the final menu for Skylab. However, the public took a dim view of the potential for inebriated astronauts in space when the news was published and NASA Cream Sherry was duly shelved.

▲ **Expedition 60 crew enjoy dinner in the Zvezda module on the ISS in 2019; their extensive menu is a vast improvement on the tubed sustenance given to astronauts in the 1960s (inset)**

Jonathan Powell is a freelance writer and broadcaster. A former correspondent at BBC Radio Wales, he is currently astronomy columnist at the *South Wales Argus*

During the Shuttle-Mir Program, American astronauts onboard the Mir space station ate mostly Russian food at the start, before slowly introducing their own foodstuffs to their fellow crew members as the missions went on. A favourite item was jello (jelly), which became a regular Sunday treat.

Today the International Space Station (ISS) boasts a veritable feast, almost as if an à la carte menu was pinned outside before entry. The seemingly lavish offerings even come with an accompaniment of condiments, such as ketchup and mustard. There are three square meals a day, plus snacking whenever you like, the aim being to ensure astronauts receive a daily intake of at least 2,500 calories.

The hours clocked up in space by astronauts are paving the way for the biggest test that faces humankind – a voyage to Mars. The goal here is to plant, grow and ultimately harvest our own food in space, and possibly on another world. Just think... even in deep space, sprouts could be on the menu.

NASA X 2

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BBC Sky at Night MAGAZINE

2022's UNMISSABLE NIGHT SKY

Charlotte Daniels looks ahead to this year's standout observing events, which neither visual astronomers nor imagers will want to miss

The coming year has plenty of astronomical events for you to witness

Our Solar System's array of planets and moons provides us with a diversity of astronomical displays throughout 2022 thanks to each planet's distinct orbit around the Sun and their changing proximities to Earth. When it comes to visual observing and astrophotography, our view of the planets changes from year to year, much more so than with deep-sky objects.

The next 12 months hold much promise for UK astronomers, with some unique planetary events and much more to look out for besides. Whether you're new to visual astronomy, an avid astrophotographer or a seasoned observer, there will be something for anyone with an interest in the night sky. Read on to find out how to prepare for a year of conjunctions, oppositions – and an increasing chance of aurora too.

The Northern Lights put on a spectacular display over the Lake District's Derwent Water, on 4 November 2021

Aurora in UK skies

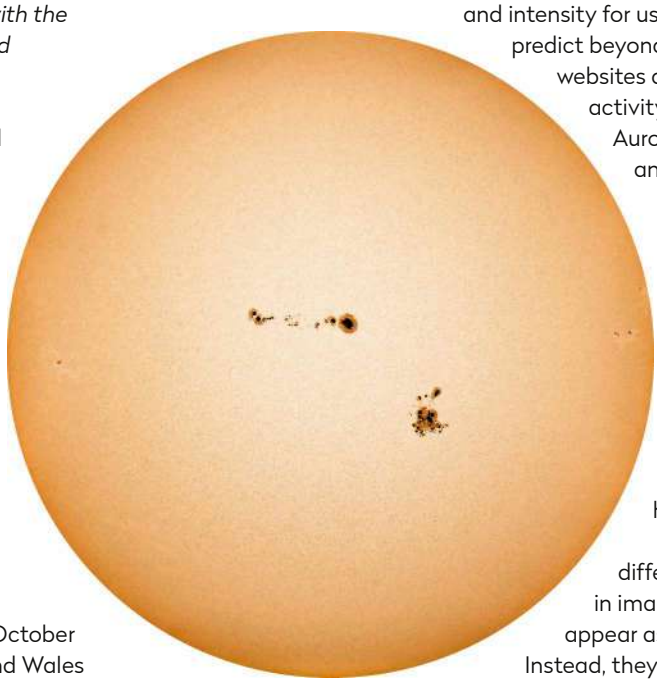
With the Sun in a more active phase of its solar cycle there's hope for more displays

When: *First quarter of 2022*
Equipment to use: *Can be seen with the naked eye, but a DSLR camera and wide-angle lens is recommend*

The Aurora Borealis is best viewed from polar locations such as Greenland and Northern Scandinavia. This is because Earth's magnetic field draws electrons from solar winds towards the poles to form the Auroral Oval at high northern latitudes. Occasionally, it can be seen from northern parts of the UK. But, due to the increasing solar activity, we may see the aurora creeping further south this year.

Indeed, 2021 finished on a high for aurora hunters in the UK, as a substantial X1-class solar flare in October allowed astronomers in Norfolk and Wales to catch a glimpse. Auroral activity usually peaks around the spring equinox, plus we're seeing further activity due to the Sun's current position in the solar cycle.

Why is this? Well, the aurora is driven by the Sun; the more 'active' it is in terms of sunspots and solar flares, the greater the likelihood of a visible display. This is because sunspots eject the solar energy that causes aurora; the more sunspots observed, the more intense the flare activity.



▲ **Increasing sunspot numbers bring an increase in auroral activity here on Earth**

The Sun goes through 'cycles' of activity, each one lasting about 11 years, during which we experience peaks and troughs; the last peak occurred in 2014. The current cycle, Solar Cycle 25, began in December 2019 and is expected to peak in 2025.

Get prepared

Observing the aurora is both a matter of timing and luck; a solar flare needs to hit at the right time and intensity for us to see it. Events are difficult to predict beyond a few hours, so check monitoring websites at the earliest mention of solar activity. Key ones to follow include AuroraWatch UK on Facebook and **www.aurora-service.eu**.

To stand the best chance of seeing a display, head for a location with a clear northern horizon. It should be as free from light pollution as possible, because the aurora is usually quite faint in the UK. Coastlines can provide a good clear northern view and remember, displays will be closer to the horizon the further south you are.

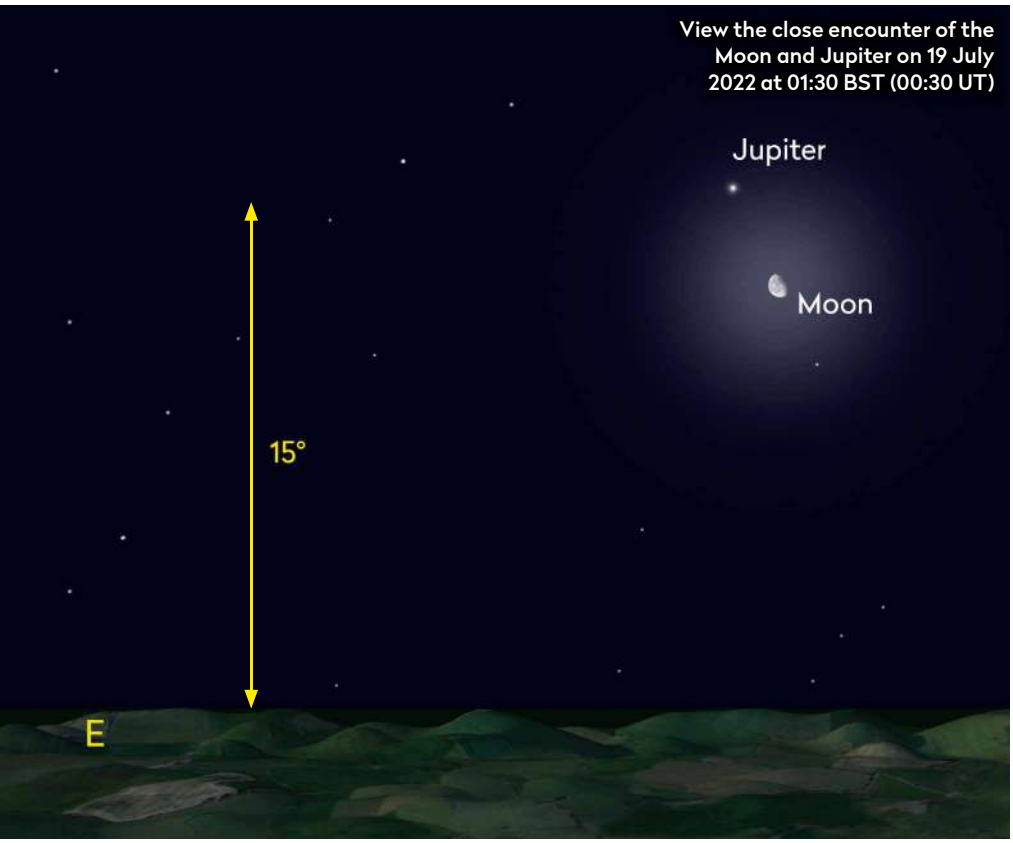
The aurora 'in real-life' looks different to how they're portrayed in images. From Britain, displays don't appear as vibrant dancing ribbons. Instead, they appear as spikes or pillars, and will be a subdued green colour. Really strong displays will show red elements higher up.

You can pick up further details by imaging the aurora. Any camera (or smartphone) that has a 'manual' mode can be used, so that you can alter the light sensitivity and exposure settings. Because aurora displays move, limit long exposure times to avoid fuzzy images – 10 seconds is a good start. ▸

JULIAN74/ISTOCK/GETTY IMAGES, PA IMAGES/ALAMY STOCK PHOTO, ALAN DYER/VWPICS/ALAMY STOCK PHOTO

A conjunction of the Moon and Jupiter

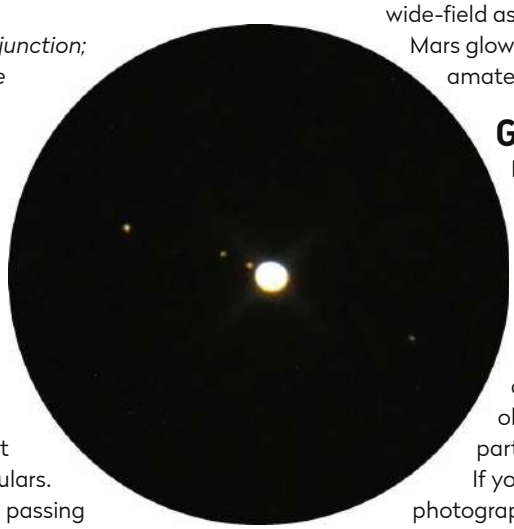
Other planets will join the display during this summer's appulse



When: *19 July 2022*
Equipment to use: *Binoculars for the conjunction; a high-powered telescope to see the three planets; a DSLR camera to get creative.*

Conjunctions provide a unique opportunity to observe planets near another celestial body, be that the Moon or another planet. In July, we'll see Jupiter get 2°13' to a waning gibbous Moon (60 per cent illuminated). Look up at the night sky to the southeast on 19 July and the two bodies will be the equivalent of a couple of little finger-widths apart. Their proximity is best appreciated by eye or with a pair of binoculars. Even though Jupiter and the Moon will be passing close together visually, they are still too far apart to fit in the same field of view with a small telescope.

While the night sky won't be fully dark, both objects are easy to spot. At about 3am, you should be able to catch Jupiter and the Moon close together, with Saturn and Mars also up. Even better, the Milky Way will be directly overhead, with the core lying to the southwest. The straight-ish line the planets form will provide an opportunity for some wide-field astrophotography too. By eye, Saturn and Mars glow a soft reddish orange, making it easy for amateur astronomers to locate them.



▲ Even through binoculars, Jupiter is a beguiling sight with the Galilean moons visible on the gas giant's flanks

Get prepared

Head to a location with clear horizons to the southeast on the 19th. The Moon and Jupiter will appear in the same field of view in a pair of low-power binoculars; however, due to the planetary activity it would be a good idea to bring a wide-aperture telescope as well to get the best views from your observing session, when the gas giant is part-obscured behind the Moon's limb.

If you're planning on some wide-field photography, any DSLR with a wide-field lens (14-35mm) will do the trick. Longer focal length lenses can still be used – pan across the view to create a panorama and capture the planets either side of the conjunction. You could also use the conjunction to try capturing a composite image. Take some images of the Moon with shorter exposures, and combine them with slightly longer exposures for Saturn, Mars and the Milky Way to create a more complete picture of the event.

Don't miss!

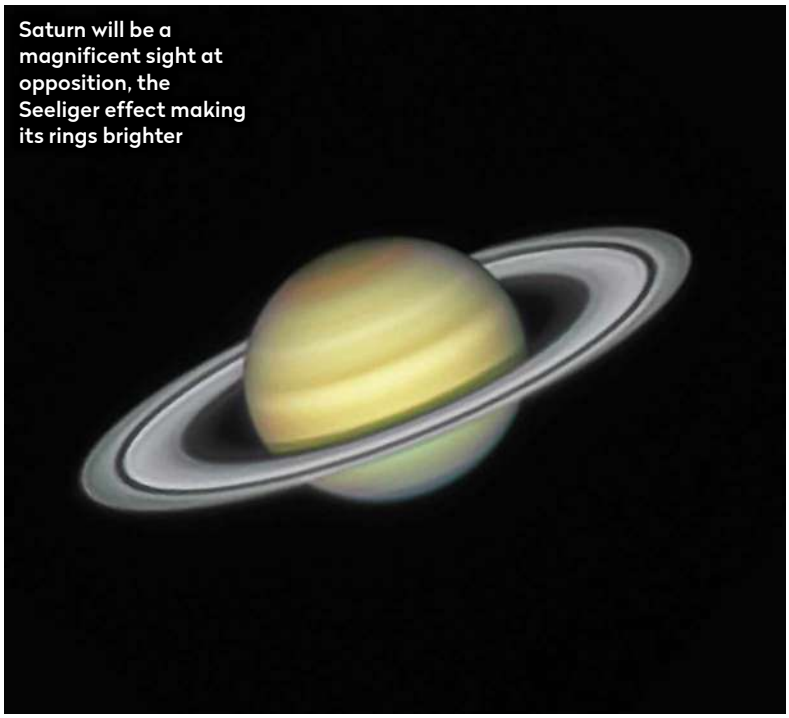
▲ Look out for Jupiter's coloured cloud bands and the Great Red Spot

Be sure to keep your eyes peeled for Jupiter on 26 September, when it reaches opposition. Cast your eyes to the south at midnight and with the naked eye you may see Jupiter as a bright white star. If the seeing is fair, even the smallest aperture telescope will allow you to see some surface detail, including bands.

CHARTS BY PETE LAWRENCE. CLAUDIODIVIZIA/ISTOCK/GETTY IMAGES, STEVE MARSH, SEBASTIAN VOLTMER/CCDGUIDE.COM

Saturn at its brightest

A relatively close approach allows Saturn to show off its amazing features



Saturn will be a magnificent sight at opposition, the Seeliger effect making its rings brighter

When: *14 August 2022*
Equipment to use: *Identifiable by eye from its golden colour. Telescopes will bring out detail, anything from a small refractor (70–80mm diameter) to a long-focal length reflector. Use planetary cameras for imaging.*

One of the most interesting planets to observe, Saturn reaches opposition in August, when it appears large and bright. Opposition occurs when Earth lies directly between the Sun and a planet – indeed, the Moon is at opposition whenever it's at full phase. It's because of this full illumination that it is so well presented. Saturn reaches opposition roughly every year, and on this occasion it'll be 8.86 AU (1.32 billion km) from Earth; that's 320 million km closer than the farthest it will be in 2022, 11 AU (1.64 billion km).

Saturn's opposition will allow observers a clear view of its northern hemisphere and ring structure. If atmospheric seeing allows and you have the equipment to achieve high magnifications, expect to see structure in the rings (such as the Cassini Division) and colouring or bands on the surface.

The great thing about Saturn, especially at times of opposition, is that even a smaller refractor in the region of 80mm will bring its rings and some level of detail into view with low-magnification eyepieces. Binoculars won't, however; they'll allow you to appreciate the colour, but not the detail.

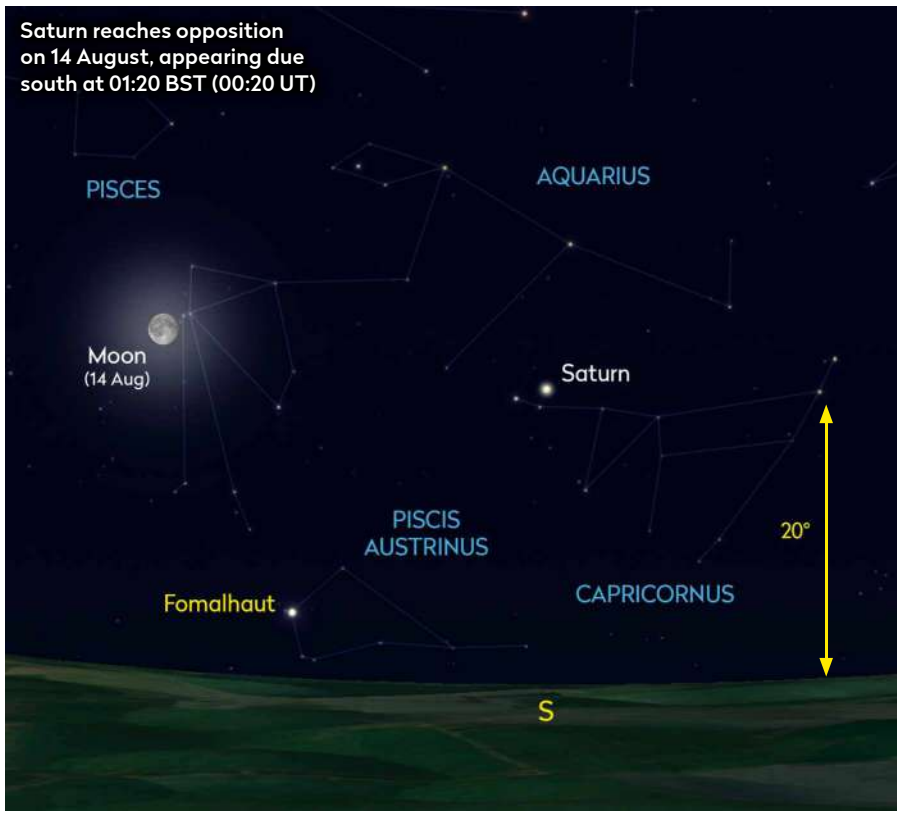
Because Saturn will be illuminated, its icy rings will brighten significantly – an occurence known as the Seeliger effect. This is a phenomenon that can be appreciated by both imagers and observers.

Get prepared

Saturn will be visible all night on 14 August, starting at twilight in the southeast. But it's best viewed or imaged around midnight, when it culminates at an altitude of around 20° in the south. Opposition gives astronomers the perfect opportunity to observe and image delicate details, however Saturn is heavily influenced by atmospheric conditions. If the seeing is poor, use lower magnification eyepieces to avoid unwanted distortion. We recommend starting with a 25–30mm eyepiece to locate it, and then stepping up eyepiece magnification until you struggle to focus or obtain a clean image.

Smaller refractors will allow you to see the rings and some level of detail at opposition using medium- to high-powered eyepieces. Some of Saturn's brighter moons should also be visible, including Enceladus. Binoculars will resolve the shape, however the rings will not be discernible from Saturn's disc, and could appear as 'ears' instead.

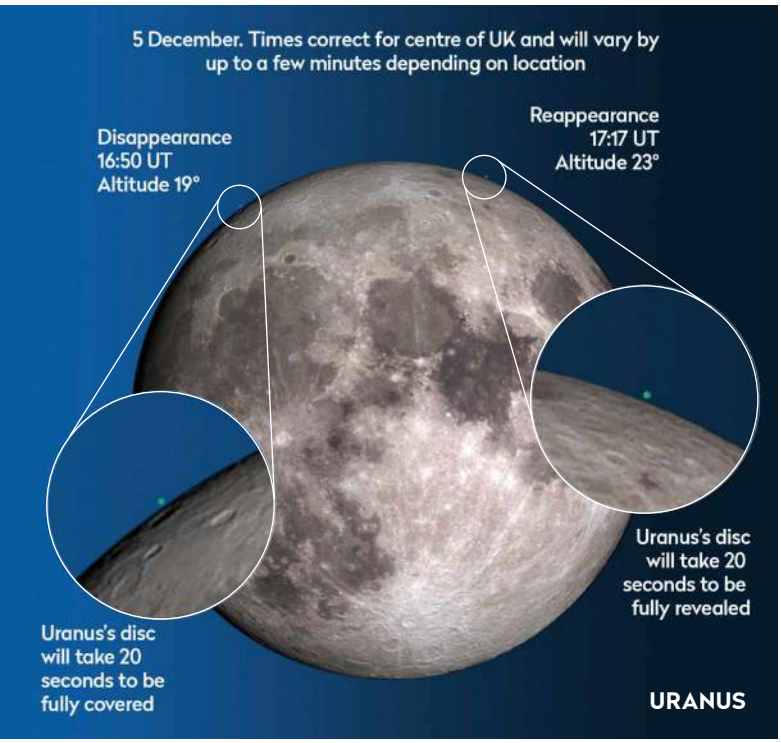
If you live in a light-polluted area, don't worry. Planets are bright and still give a pleasing view, although you will lose a nice dark background for contrast, and views of the moons. ▸

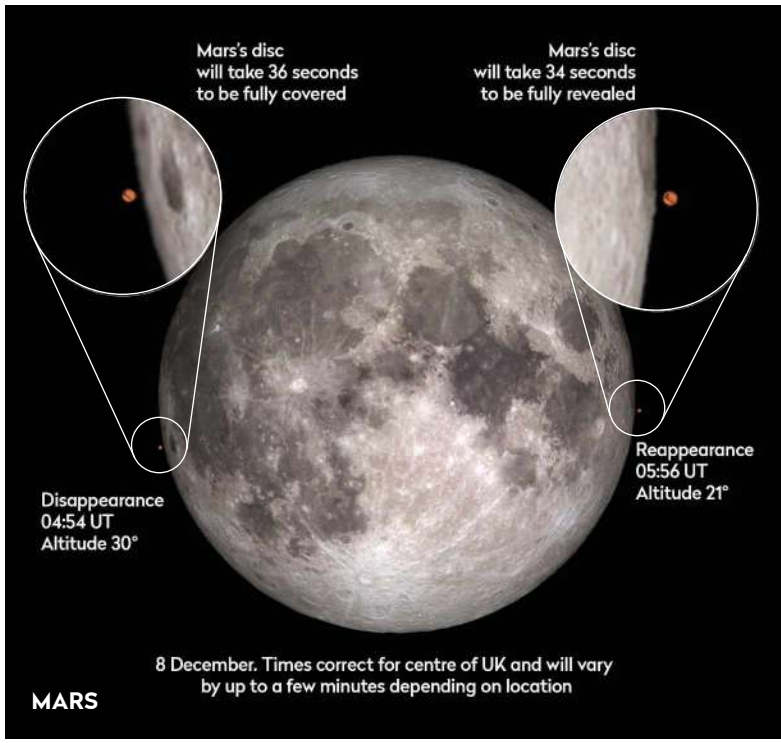


Saturn reaches opposition on 14 August, appearing due south at 01:20 BST (00:20 UT)

Occultations of Uranus and Mars

Two of Earth's neighbours perform disappearing acts during December


5 December. Times correct for centre of UK and will vary by up to a few minutes depending on location
Disappearance
16:50 UT
Altitude 19°
Reappearance
17:17 UT
Altitude 23°
Uranus's disc will take 20 seconds to be fully revealed
Uranus's disc will take 20 seconds to be fully covered
URANUS


Mars's disc will take 36 seconds to be fully covered
Mars's disc will take 34 seconds to be fully revealed
Disappearance
04:54 UT
Altitude 30°
Reappearance
05:56 UT
Altitude 21°
8 December. Times correct for centre of UK and will vary by up to a few minutes depending on location
MARS

When: *Uranus – 5 December 2022 and Mars – 8 December 2022*
Equipment to use: *For Uranus, long focal-length telescopes with large apertures (200mm+) are needed to ensure it appears larger than a speck. Use high frame-rate planetary cameras for imaging.*

For Mars, a reflecting telescope (125mm+) will show details before the Moon washes out too much detail. Consider moving to a lower magnification telescope and eyepiece for the occultation.

▲ Above left: the occultation of Uranus on 5 December begins in a bright post-sunset sky

Above right: on 8 December the Moon occults Mars while the Red Planet is also at opposition

December welcomes two lunar occultations within a few days of each other, when two different planets pass behind the Moon, 'disappearing' on one side before 'reappearing' on the other. Because of parallax, occultations are location dependent; one place may see it, while others won't because their view of the event can put the two objects further apart.

First, watch as Uranus disappears behind the Moon due east, in the constellation of Aries, the Water-Bearer. Catch it about an hour after sunset. While not fully dark, UK astronomers should be able to see it.

To find Uranus as it occults, pop an RA of 02h52m40s and a dec. of 16°08'N into your Go-To. If you are looking at the Moon as a clock face, Uranus will disappear at the 10 o'clock position, at 16:46 UT. It then reappears at 17:23 UT in the 1 o'clock position.

Mars's lunar occultation follows early on 8 December, when the Moon is at full illumination. Mars will also be at opposition, at 0.54 AU (81 million km) from Earth. The relative distance between Mars and Earth won't be as small as this again until May 2031, making December 2022 one of the standout occasions to view Mars through a telescope in many years! UK observers can see both the disappearance and reappearance of Mars, meaning a good opportunity for imagers to capture a composite sequence.

Set your alarm for about 04:30 UT and look to the west, where the Moon will be at an altitude of 29° between Taurus, the Bull and Auriga, the Charioteer. Mars disappears at 04:55 UT and reappears at 05:56 UT while the Moon is still 20° above the horizon.

Get prepared

Expect Uranus to appear as a tiny blue-green disc; it's challenging not only due to its distance, it's also not as illuminated by the Sun as the inner planets. A 94 per cent illuminated Moon may disrupt views as the planet gets closer. Imagers can vary short exposures to capture both bodies, boosting ISO or gain to increase signal from Uranus. Don't expect to capture surface detail without infrared filters.

Because Mars is also at opposition, observers and planetary imagers might want to make a night of it and view Mars from 20:00 UT on 7 December. Find a clear western horizon to capture the full occultation early the following morning; Mars disappears at the 10 o'clock position and reappears at about 4 o'clock.

PETE LAWRENCE X 2, RWITTICH/ISTOCK/GETTY IMAGES

2022's top deep-sky target:
Markarian's Chain

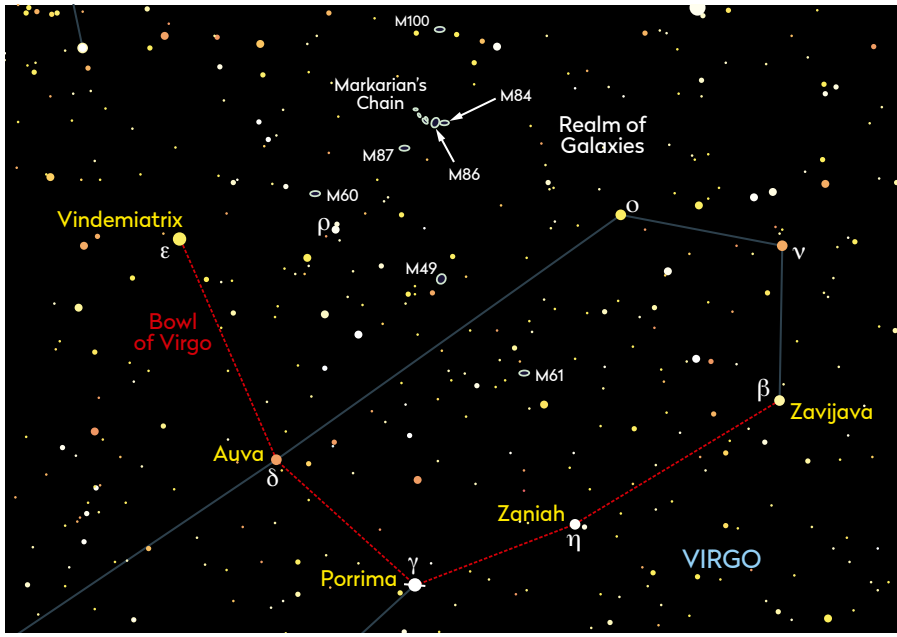
This meandering line of galaxies makes for an excellent imaging target

When: *Most visible March to June 2022*
Equipment to use: *A 75mm refractor to 200mm reflector should provide excellent views. To capture the whole chain, a DSLR and long lens (300mm focal length) does the job nicely.*

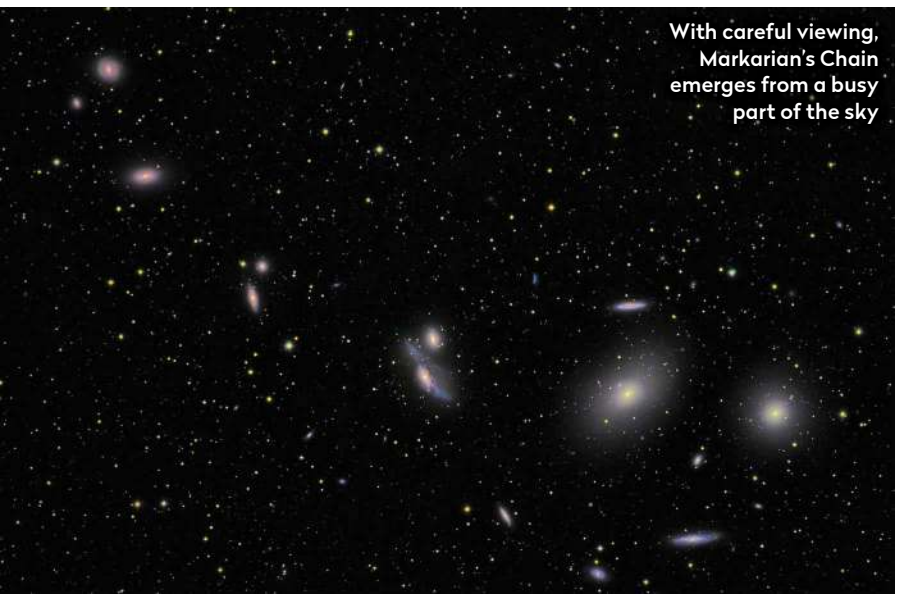
A great spring and early summer target, Markarian's Chain is unique in that it's just a small part of the huge Virgo Cluster of galaxies; if you point your scope in its vague direction, you will doubtless land on a galaxy-rich landscape. Markarian's Chain is a string of large spiral and lenticular galaxies. The main belt is made up of seven bright galaxies including M84 and M86. There is also a pair of interacting Galaxies (NGC4435 and NGC4438) known as Markarian's Eyes. Other dimmer galaxies float alongside.

You'll be able to pick up brighter parts of the chain with a pair of 100mm binoculars in dark skies, but a telescope is better. Markarian's Chain can be viewed with a small refractor to see the whole chain, however you will still see the brighter galaxies as fuzzy white blobs. Medium power eyepieces of around 15mm focal length allow you to get in a little closer. For detail, use a longer focal length and a larger aperture such as a 200–250mm reflector, and hop from galaxy to galaxy along the chain.

Where Markarian's Chain really comes into its own is as an imaging target; a DSLR tagged onto the end of a 70mm refractor will capture it. Stacking about an hours' worth of 1-2 minute exposures is a good start.



▲ The galaxies of Markarian's Chain lie along a smoothly curved line; find them just above the Bowl of Virgo



With careful viewing, Markarian's Chain emerges from a busy part of the sky

Get prepared

The Virgo Cluster consists of around 2,000 galaxies. Due to the cluster's size and sheer number of objects in it, finding Markarian's Chain can be problematic. A Go-To setup will help here, as you can search for one of the brighter galaxies – like M86 – to locate it. By eye, draw a straight line between the stars Denebola in Leo, the Lion, and Vindemiatrix in Virgo, the Virgin; the chain is about halfway between. Galaxies are delicate objects to observe, so ensure your eyes are fully dark adapted (at least 20 minutes) when observing.

A dark site will help reveal fainter galaxies in 150–200mm aperture telescopes. Larger galaxies will still be visible under mild light pollution but quickly get washed out as you climb up the Bortle scale into greater light pollution. Because of this, it's also best to view at new and early Moon phases.

Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

How to take an award-winning ASTROPHOTO

As the Astronomy Photographer of the Year competition opens for entries, **Katie Sawers** spoke to previous winners and this year's judges to get their tips on capturing a best-in-class image

February is here once again, and that means the 14th Astronomy Photographer of the Year competition is now open for entries. Run by the Royal Observatory Greenwich and supported by Liberty Specialty Markets, it is the world's biggest astrophotography competition.

Every year since 2009 the competition showcases an incredible mix of technical expertise and artistic flourish from talented astrophotographers around the globe. It welcomes photographers of all ages and experience to submit their best astro images across a variety of categories in the hope of scooping the top prize, as well as the chance to have a photo displayed in an exhibition at the National Maritime Museum later in the year.

But what does it take to create an award-winning astrophoto? We asked some of this year's judges and previous winners for top tips. If you're considering entering this year's competition, read on...

Katie Sawers is a science writer specialising in cosmology and the history of astronomy

Astronomy Photographer of the Year

Supported by
Liberty Specialty Markets

The overall winner of the 13th competition last year was Suchang Dong's image of an annular eclipse from Tibet

Melissa Brobby
2022 judge

The competition is a wonderful way to showcase the astronomical objects that can be seen – whether that's with the naked eye, with a telescope or through a camera lens – to get people's imaginations flared up about what exists beyond our planet. As a judge I'm looking for an image that makes you stop in your tracks, which makes all else fall away because you're so engrossed in what you're looking at. It should take your breath away. I find that the images that tend to do that are the ones that contain a human element in them.

Perhaps you're inspired to take part in this year's competition but don't know how to start. I would advise just learning as much as you can about astrophotography and then practise, practise, practise. If you're happy with what you've produced, brilliant; share it! You never know, it might be one of the images we end up choosing and, if not, that's fine because you will have produced an image you can be proud of. You can take that and continue to expand on that knowledge and expand on that interest. That's always my motto: just give it a go. ▸

The winners' viewpoint

Past champions offer advice on how to capture award-winning images

Nicolas Lefaudeux
2020 winner

Creating a good astrophoto is more about originality and composition than pure technique.

It is really astronomy photography: it's the artistic element and what the image inspires that matters more than the technical quality.

What motivates me are interesting ideas, difficult projects or something that has not been done very much – if at all – before. You might produce an interesting or even a winning image, or maybe it will turn out not so interesting, but that's how you produce something that will grab people's attention: it's something they haven't seen before. The taste of the judges, and how people react to it, is the mystery of the art.

Nicolas's overall winning image from the 12th competition in 2020, 'Andromeda Galaxy at Arm's Length?'

From looking back at past entries, I think that the competition has gone from being very technical at the start, to being more artistic and more about composition. By going in this direction it means more people can enter and produce images that are different and will be of interest.

Brad Goldpaint
2018 winner

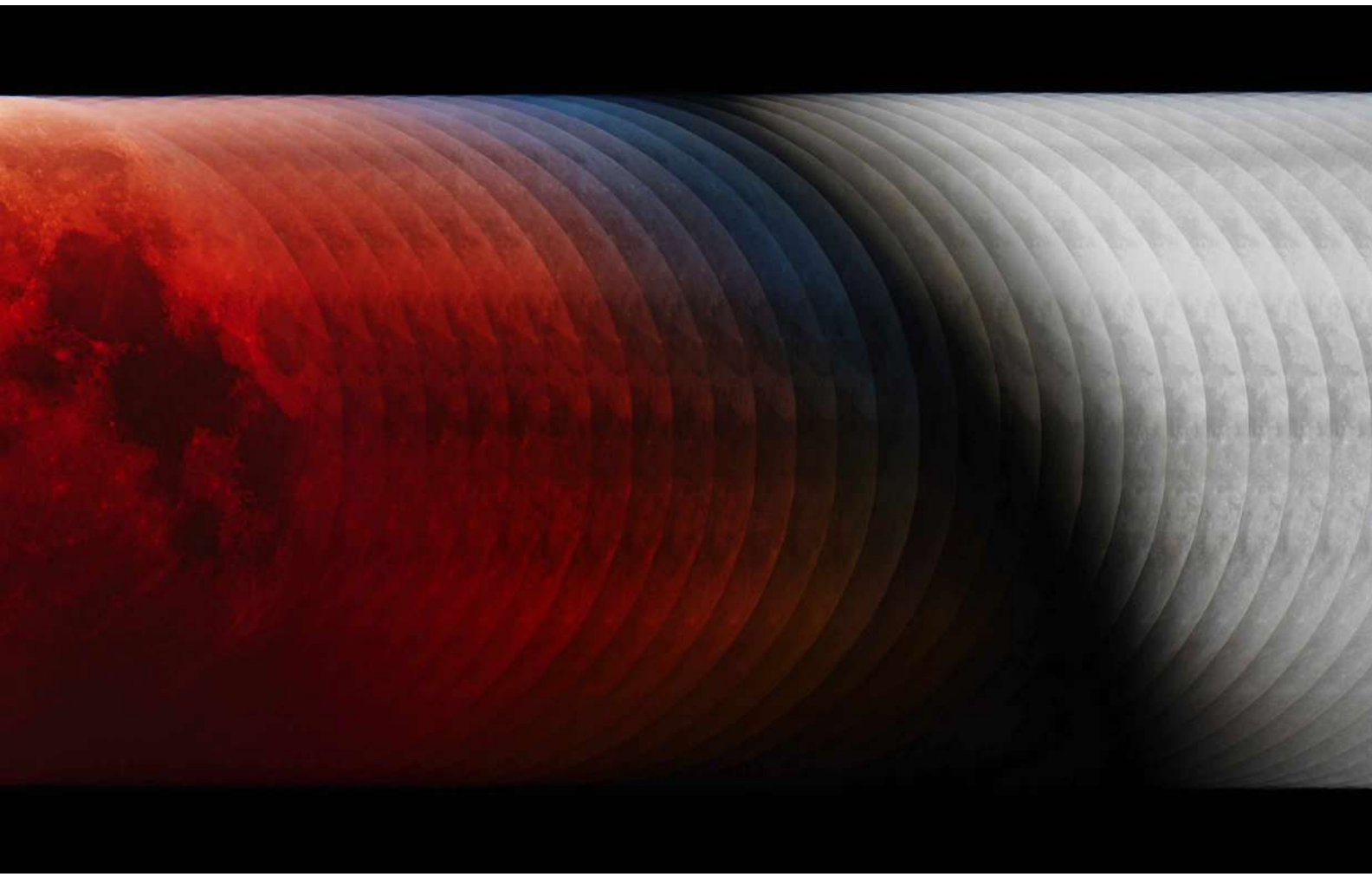
Remain authentic to who you are as a photographer, and if you do not know what that is, find it for yourself. This is essential for being able to convey your unique voice through visual media. Secondly, remain true to the beauty of the night. The night is filled with magical moments from the cosmos, so try and avoid digitally over-enhancing an already spectacular display.

Planning can put you in the right place at the right time for a special event, but be open to unexpected surprises; negative or positive.

Some of my images have taken over five years to fully capture; when all the various elements align and you achieve that serendipitous moment, taking the picture can often be the easiest part.

'Transport the Soul' by Brad Goldpaint was crowned the overall winner of the 10th competition in 2018

Lastly, one of my secrets for choosing an image is my wife. She waits until the images are complete and experiences her first visceral response without any preconceived ideas. Eliciting a positive emotional reaction from an image is a wonderful gift.



László Francsics's 'Into the Shadow', an innovative composite image of a lunar eclipse, won the 11th competition in 2019

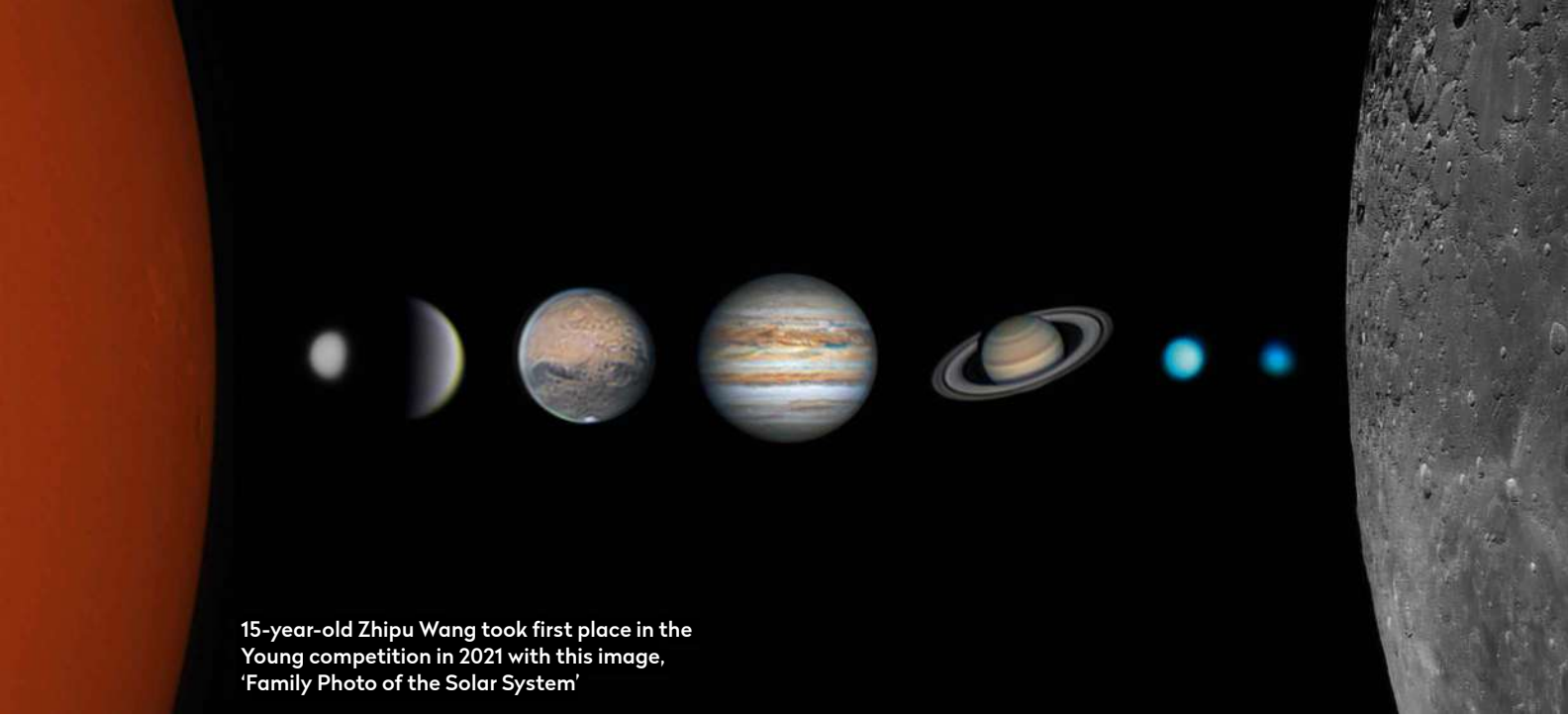
'Polar Lights Dance' by Dmitrii Rybalka, the Aurora category winner of the 13th competition last year

László Francsics
2019 winner, 2022 judge

Don't look at astrophotos as 'documentarist' images that happen to depict celestial objects. Think of them as a means of expressing artistic thoughts about the world and also about humanity, combined with the highest-level representation of the celestial bodies. Perfection is not the goal, but it is a criterion.

The best photos in the competition are perfect according to almost all criteria, and on top of that they can suggest something more: novelty, a relevant message and a unique vision. I can't suggest tips on these because everyone has to find them for themselves and within themselves. However, I can give advice on the perfect technical and photographic solutions. Never forget the rules of good composition: the image should always have its dynamics and the contrast and colour chosen according to the theme. Make the image sharp, the background homogeneous, and black should be black (only close to black for deep-sky photos).

Make the photo look natural, but at the same time captivating, possessing a strong visual impact. Make it stand out, but don't overdo it. ▸



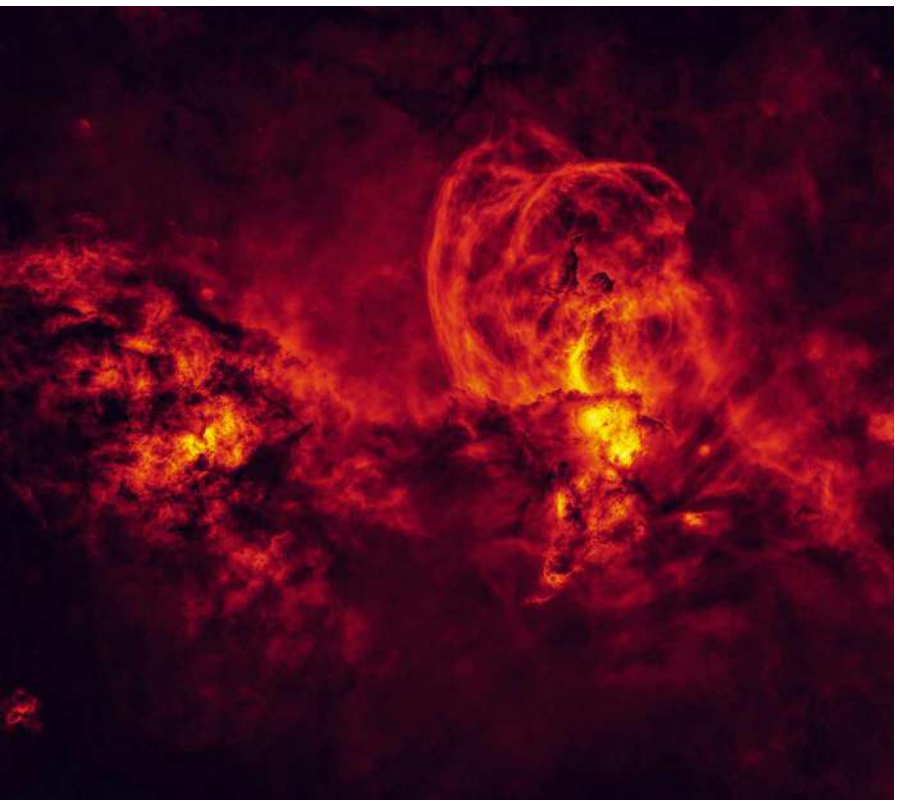
15-year-old Zhipu Wang took first place in the Young competition in 2021 with this image, 'Family Photo of the Solar System'

Emily Drabek-Maunder
2022 judge

An entry needs to have a bit of everything to stand out from the crowd. The most striking astrophotos are visually engaging, technically challenging and tell an interesting story. I love images of our Solar System, particularly planets and moons. They can be challenging to observe, but I enjoy seeing new and creative ways to photograph these objects. From capturing the phases of Venus to the bright blues and greens of our outermost planets, astrophotographers can be innovative and reimagine how we picture these worlds.

Like most people, I am often in awe when I see photos of our cosmos. Space is a completely alien place to humans, unfathomably large and extraordinarily beautiful. My background in astronomy influences the way I look at astrophotography by helping me understand the context of what I am looking at.

As an astronomer, I have studied everything from distant galaxies to the formation of solar systems in our own Galaxy. The science happening inside galaxies, nebulae and other places in space is just as moving and fascinating as their striking appearances. I love understanding the story of what is happening beneath the surface of these images and communicating that with people.



'Cosmic Inferno' by Peter Ward, the Stars and Nebulae category winner in the 2020 competition

Jon Culshaw
2022 judge

Each year we think the competition can't get any better than the year before, but every year it seems to. After the entries have been looked at and the shortlist produced, those images will be sent across to me, and I look at them utterly mesmerised. It's like space travel from your own armchair. Some captures are very quick – there's been a serendipitous grab and a wonderful picture has come up – while other images are produced by experts who are really experienced, so you get a wonderful mix. To look through all those for the first time really leaves you in awe.

Then we get to the judging day. The technical people come in – maybe previous winners, people who've made some of those fantastically technical images we remember from past years. I tend to come in with another view, that of an amateur astronomer. I look for something scientifically fascinating, but which visually has that impact as well, so it's a blend of perspectives. There are times judging day can be quite argumentative, because people have built up these almost emotional connections to certain images. You want to champion them. People think, "That's one of mine, I feel strongly about that one," and they will shout and stick up for it!

Astronomy Photographer of the Year

Supported by Liberty Specialty Markets

HOW TO ENTER

All you need to know to enter the world's biggest and best astrophotography competition

The 2022 Astronomy Photographer of the Year competition is open for entries, and a grand prize of £10,000 is up for grabs. Entrants are allowed to submit up to 10 images across all of this year's categories, and there are prizes of £1,500 for the winning images in individual categories, including the Young Astronomy Photographer of the Year. Runners up and Highly Commended entries will win £500 and £250 respectively.

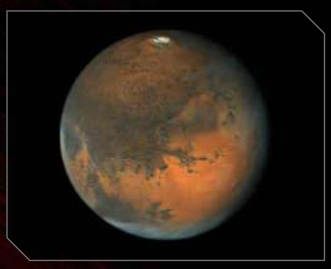
And don't forget, you can still vote for your favourite image of 2021 by taking part in the People's Choice Award. Visit **https://bit.ly/apypeopleschoice2021**

Here are #APY14's 11 categories. You can enter each one multiple times:

Dates for the diary

Competition opens: 10 Jan 2022
Entry closing date: 4 Mar 2022
Entrance fee: £10 for up to 10 images
People's Choice closes: 20 Feb 2022

How to enter and rules: Find out more by visiting the Astronomy Photographer of the Year website: **www.rmg.co.uk/astrocomp**



Planets, Comets and Asteroids

A celebration of our cosmic neighbourhood. Will Comet A1 Leonard make the shortlist?

Aurorae

The Northern and Southern Lights are among nature's most beautiful displays.

People and Space

Exploring the connection between humanity and the wonderful night sky above.

Skyscapes

Landscapes or cityscapes with a focus on celestial objects and dazzling starry night skies.

Our Moon

The ever-changing face of the Moon offers a host of astro imaging opportunities.

Our Sun

Recent solar activity could make this category the one to watch in the 2022 competition.

Stars and Nebulae

There are countless beautiful sights to be discovered in these ethereal deep-sky objects.

Galaxies

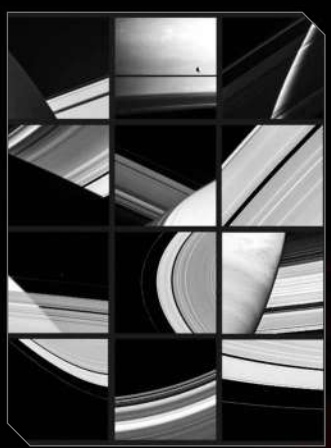
The Universe is home to billions of galaxies, providing ample astrophoto opportunities.

Young Astronomy Photographer of the Year

Showcasing the best new talent. Open to entrants under 16 years of age.

Special Prize: Prize for Best Newcomer

Never photographed the night sky before? This category is for those finding their imaging feet.



Special Prize: Annie Maunder Prize for Image Innovation

This special prize asks entrants to process data from professional sources in an innovative way. Each year entrants create beautiful false-colour images, combining data from multiple Earth-based observatories and robotic space missions to produce mindblowing spectacles.

Shooting for the Moon

NASA's newest rocket, the Saturn V-sized Space Launch System, will take human exploration beyond low-Earth orbit once more

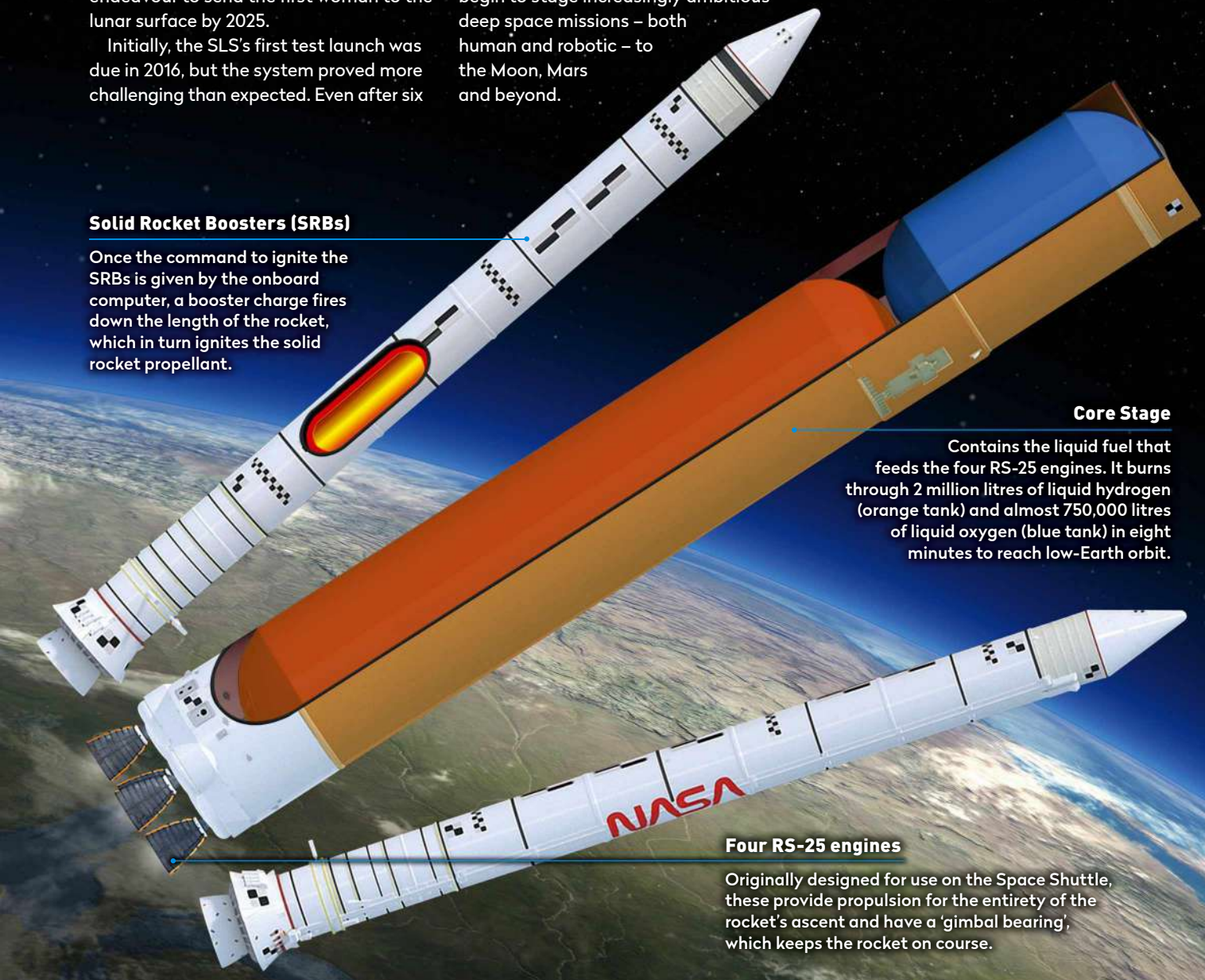
When the Space Shuttle programme shut down in 2011, NASA was left unable to launch heavy payloads into orbit. But that will soon change as the agency prepares to launch its Space Launch System (SLS) in March or April of this year. The SLS will eventually carry payloads of up to 45 tonnes to lunar orbit and is a key part of the Artemis programme, NASA's endeavour to send the first woman to the lunar surface by 2025.

Initially, the SLS's first test launch was due in 2016, but the system proved more challenging than expected. Even after six years' delay, the 2022 SLS is not the final version. The first three launches will use the Block 1 design shown here, followed by a Block 1B version with a more powerful upper stage, before being replaced by a Block 2 design with even more thrust. But even in Block 1, SLS will produce 15 per cent more thrust than the Saturn V.

Currently, NASA's budget allows one SLS a year to be produced at most. The first three have all been earmarked for the Artemis programme and, with a successful test this spring, NASA will begin to stage increasingly ambitious deep space missions – both human and robotic – to the Moon, Mars and beyond.

SLS Block 1 by numbers

Height: 98m
Weight: 2.6 million kg
Payload weight to low-Earth orbit: 95 tonnes
Payload weight to the Moon: 27 tonnes
Thrust: 39 million newtons
Solid fuel: Polybutadiene acrylonitrile
Liquid fuel: Oxygen and hydrogen
Top speed: 39,500km/h



Solid Rocket Boosters (SRBs)

Once the command to ignite the SRBs is given by the onboard computer, a booster charge fires down the length of the rocket, which in turn ignites the solid rocket propellant.

Core Stage

Contains the liquid fuel that feeds the four RS-25 engines. It burns through 2 million litres of liquid hydrogen (orange tank) and almost 750,000 litres of liquid oxygen (blue tank) in eight minutes to reach low-Earth orbit.

Four RS-25 engines

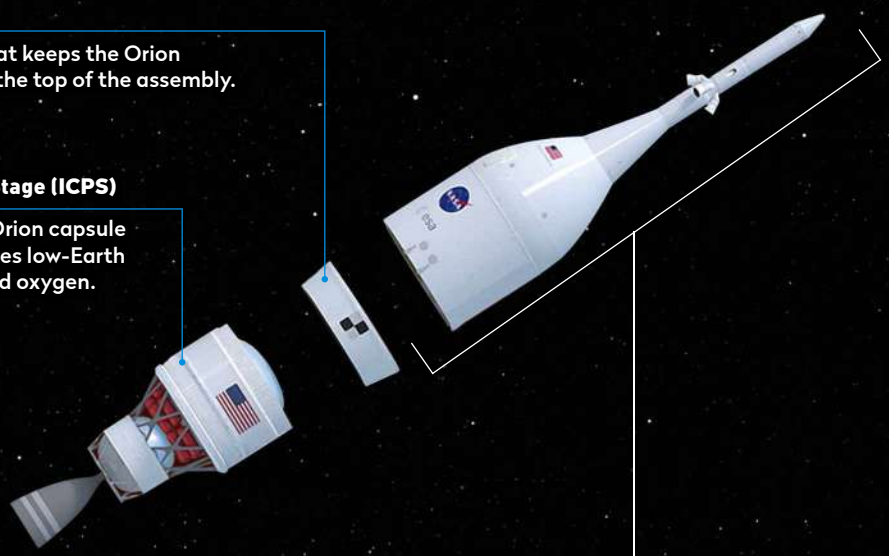
Originally designed for use on the Space Shuttle, these provide propulsion for the entirety of the rocket's ascent and have a 'gimbal bearing', which keeps the rocket on course.

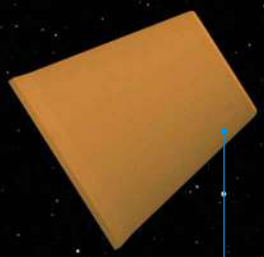
Orion stage adaptor

A ring-shaped device that keeps the Orion spacecraft attached to the top of the assembly.

Interim Cryogenic Propulsion Stage (ICPS)

The ICPS is used to propel the Orion capsule towards the Moon once it reaches low-Earth orbit. It uses liquid hydrogen and oxygen.



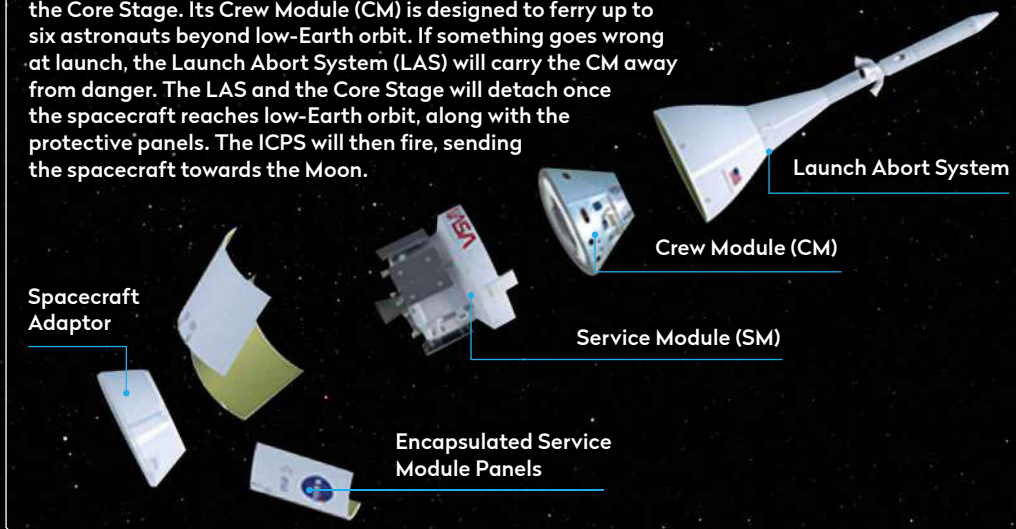


Launch Vehicle Stage Adaptor (LVSA)

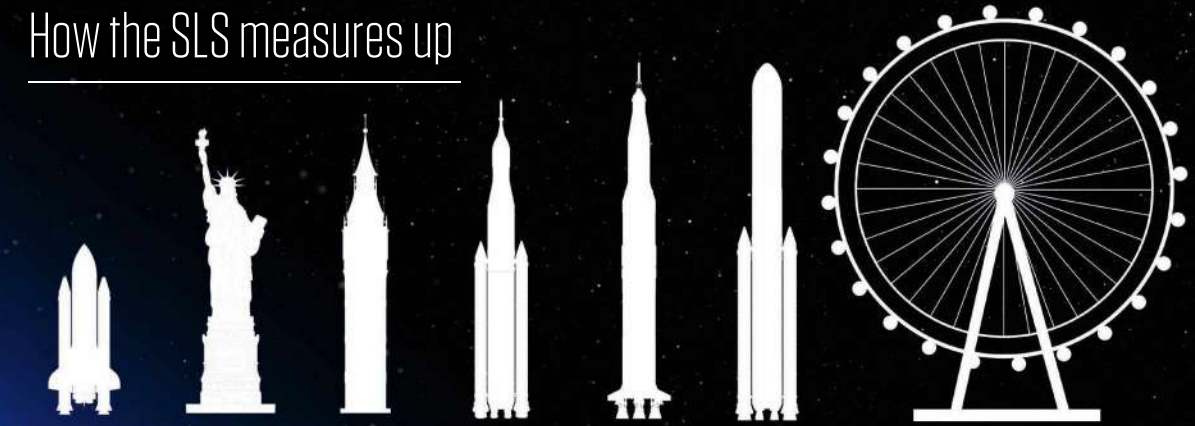
A 9m-tall cone that connects the upper and lower stage, encasing the ICPS (Interim Cryogenic Propulsion Stage).

Orion spacecraft

The Orion spacecraft will begin its journey attached to the top of the Core Stage. Its Crew Module (CM) is designed to ferry up to six astronauts beyond low-Earth orbit. If something goes wrong at launch, the Launch Abort System (LAS) will carry the CM away from danger. The LAS and the Core Stage will detach once the spacecraft reaches low-Earth orbit, along with the protective panels. The ICPS will then fire, sending the spacecraft towards the Moon.



How the SLS measures up



BJORN HOLLAND/ISTOCK/GETTY IMAGES, NASA X 2

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

FEBRUARY 2022

AMAZING SHAPES ON THE MOON

View the Lunar X and V clair-obscur effects on the first quarter Moon

EVENING ENCOUNTER

Catch Jupiter with a waxing crescent Moon on 2 February

ASTEROID WATCH

Observe 11 Parthenope as it reaches opposition in Cancer

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- Comets C/2019 L3 Atlas and 19P/Borrelly
- Mars and Venus in the morning sky
- Open cluster M35, best placed in early evenings

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

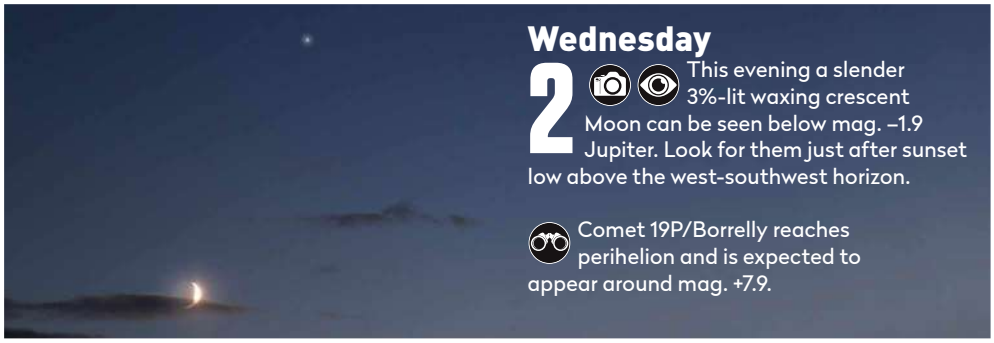
Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

FEBRUARY HIGHLIGHTS

Your guide to the night sky this month

Tuesday
1 The Moon is new today, meaning the sky will be good and dark. This is just as well as there's a lot to see, including two reasonably bright comets; C/2019 L3 Atlas and 19P/Borrelly. Turn to page 46 to find out how to locate them.



Wednesday
2 This evening a slender 3%-lit waxing crescent Moon can be seen below mag. –1.9 Jupiter. Look for them just after sunset low above the west-southwest horizon.

Comet 19P/Borrelly reaches perihelion and is expected to appear around mag. +7.9.

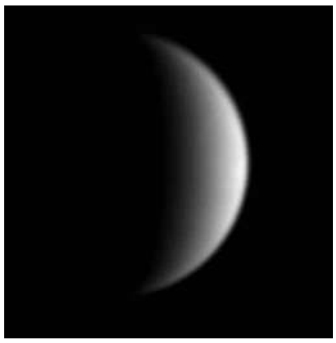
◀ Sunday
6 The libration seas – Mare Smythii and Mare Marginis – can be seen near the Moon's eastern limb at the moment. As they are so close to the limb, the libration (the Moon's rocking motion) and phase has to be favourable to see them properly.

Monday
7 This evening's 43%-lit waxing crescent Moon sits 1.5° to the south of Uranus. Mag. +5.8 Uranus is currently paired up with 29 Arietis, the mag. +6.0 star appearing 24.5 arcminutes north of the planet.

Wednesday ▶
16 Mercury reaches greatest western elongation, appearing separated from the Sun by 26.3° in the morning sky. The planet shines at mag. +0.1 and rises an hour before the Sun.

◀ Thursday
24 The underrated open cluster M35 in Gemini, the Twins, reaches its highest position in the sky, due south at 20:00 UT. With the Moon out of the way this is a great time to view it.

Saturday
26 Often overshadowed by its brighter sky neighbour Sirius (Alpha (α) Canis Majoris), Mirzam (Beta (β) Canis Majoris) marks the front leg of the Great Dog, Canis Major. It is February's 'Star of the Month' on page 53.



◀ Sunday
27 Spot a morning grouping of Venus, Mars and the Moon. Find mag. –4.5 Venus in the dawn sky, with mag. +1.3 Mars 5.3° below it. The 15%-lit waning crescent Moon is 4.8° to the south of the Red Planet.

Monday ▶
28 A clear sky and binoculars will give you a breathtaking view of the Beehive Cluster, M44, at the heart of Cancer, the Crab. Catch it near its highest position in the sky, due south, around 22:00 UT.

PETE LAWRENCE X 9

Thursday 3

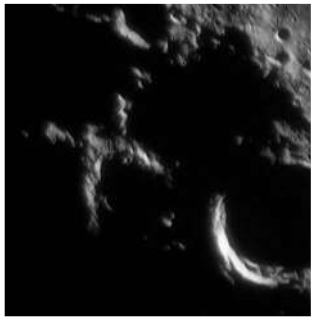
The mag. +8.0 planet Neptune appears 1.4 arcminutes to the north of mag. +6.3 HIP 115953.

Friday 4

With the Moon in its early waxing phase and setting just after 21:00 UT, this evening is a great time to attempt our 'Deep-sky tour' on page 56, focusing on the area around the Sickle asterism in the constellation of Leo, the Lion.

Saturday 5

Minor planet 20 Massalia reaches opposition at mag. +8.5. Massalia is currently located in Cancri, the Crab, beginning its monthly track near mag. +5.4 Pi (π) Cancri. See page 53 for more details.



◀ Tuesday 8

The popular clair-obscur effects known as the Lunar X and V will appear at 17:52 UT on the Moon's terminator.

Lunar crater Walther also sits on the terminator this evening. See page 52.

Thursday 10

Minor planet 11 Parthenope reaches opposition at mag. +10.0 today. Parthenope is currently located in Leo, the Lion, just west of the Sickle asterism.

Friday ▶ 18

Mag. −4.5 Venus and mag. +1.3 Mars are 6.1° apart this morning. Catch them low above the southeast horizon from approximately 1 hour before sunrise.

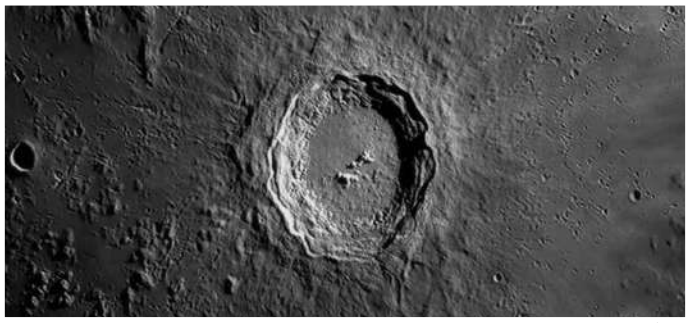
Wednesday 23

Look at the region between Leo and Boötes around midnight to spot a faint, triangular shimmer of stars about 4°, or 8 apparent Moon diameters, in height. This is the open cluster Melotte 111.

Friday ▶ 25

Minor planet 471 Papagena is at opposition, located in Leo, the Lion.

The lunar crater Copernicus can be seen next to the terminator on this morning's Moon.



Family stargazing

The months at the start of the year are good for early evening views of the Moon. Provide your budding observers with some white paper, a soft pencil and something to rest the paper on, such as a clipboard. When the Moon is in the evening sky during the first half of the month, set a challenge to draw it. Begin with the Moon's shape; its phase. When the outline is drawn, ask about its brightness as a guide to identifying the darker sea areas. Mention that although they are called 'seas,' they are dark solidified lava. Set a new challenge to add these to the drawing: **bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

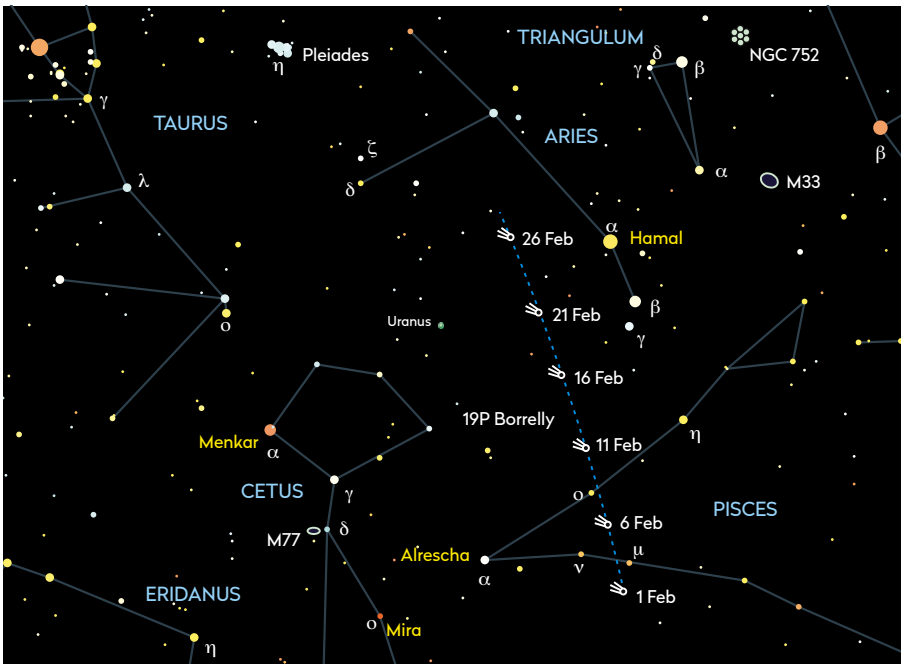
THE BIG THREE

The top sights to observe or image this month

DON'T MISS

Comets C/2019 L3 Atlas and 19P/Borrelly

BEST TIME TO SEE: 1-4 February and 19-28 February



▲ **Comet 19P/Borrelly makes a good binocular target as it heads northeast through Pisces...**

Last month, Comet C/2019 L3 Atlas reached perihelion in Gemini, when it appeared at its brightest, hovering about 10th magnitude. This month, L3 Atlas continues to be well positioned for UK viewing and, if it behaves as predicted, will remain around 10th magnitude, making it an object for larger binoculars and small telescopes.

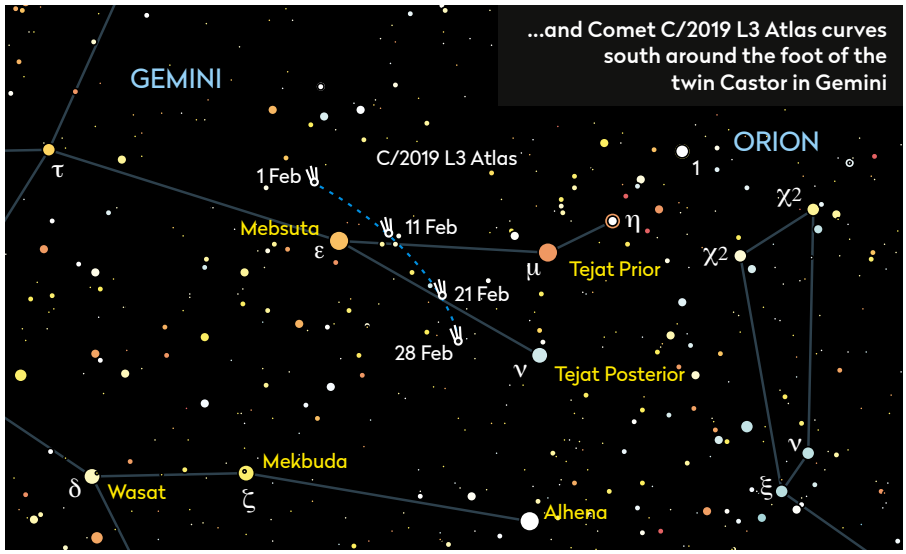
Discovered by the ATLAS (Asteroid Terrestrial-impact Last Alert System) facility at Haleakala, Hawaii on 10 June 2019, the comet has been a steady performer for many months. It begins its February track 2° north of mag. +3.0 Mebsuta (Epsilon (ε) Geminorum). From here it tracks into the main shape of western Gemini, the Twins curving south to end the month 2° northeast of mag. +4.1 Nu (ν) Geminorum. This places it near the stars forming the foot of the twin Castor, which is a distinctive area thanks to the presence of open cluster M35. The cluster is located about 6° to the west-northwest of L3 Atlas at the end of February and a mid- or wide-field photograph should capture both objects easily.

C/2019 L3 Atlas isn't the only reasonably bright comet visible this month. Comet 19P/Borrelly heads northeast through Pisces, the Fishes and into Aries, the Ram in February. 19P/Borrelly reaches perihelion on 2 February, and from the middle of January to 4 February it is expected to appear at mag. +8.0, making it a good target for binoculars and small telescopes.

The comet has been moving northeast and this month it will be favourably located. At February's start, it's positioned south of the narrowing pattern of stars converging on Alrescha (Alpha (α) Piscium). Use mag. +4.9 Mu (μ) Piscium and +4.4 Nu (ν) Piscium to locate it. 19P/Borrelly then tracks northeast, passing Mu Piscium by 0.6° on the evening of the 3rd and missing mag. +4.3 Omicron (ο) Piscium by 0.5° on the evenings of the 7th and 8th.

The comet slips across the border of Pisces and Aries on the 9/10 February, and on the evening of the 21st it appears 5° northwest of Uranus. As it continues tracking northeast, it ends the month close to mag. +5.5 Nu (ν) Arietis. At this time 19P/Borrelly lies 7° north of Uranus.

19P/Borrelly should appear brightest at February's start, at mag. +7.9. By mid-month it's predicted to be mag. +8.1, and it will be down to mag. +8.5 by the month's close. Despite its slow decline, these magnitudes are still respectable for a comet and 19P/Borrelly should remain a decent binocular target for the month.



...and Comet C/2019 L3 Atlas curves south around the foot of the twin Castor in Gemini

ALL PICTURES: PETE LAWRENCE

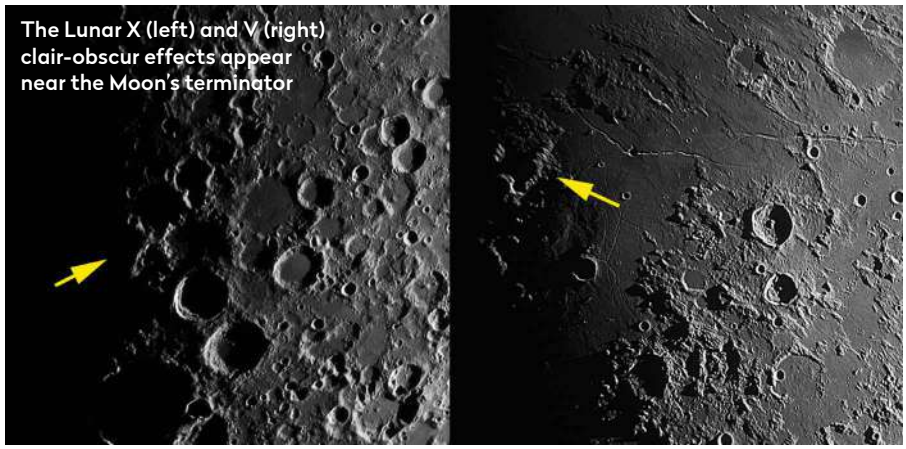
Catch the Lunar X and V

BEST TIME TO SEE: Early evening, 8 February

The Lunar X and V are popular light and shadow effects, visible close to when the Moon reaches first quarter. They belong to a growing list of clair-obscur effects; light and shadow arrangements that appear like familiar, everyday things.

Clair-obscur effects can last for several days or, as is the case here, just a few short hours. The Lunar X and V take on the appearance of the letters X and V, glowing within the lunar terminator shadow. Best seen through a small scope, they are formed when the lunar dawn's light hits elevated features, while the lower-level terrain remains in darkness.

The Lunar V is formed when elevated ridges near the 23km crater Ukert become illuminated. The arms of the V are a bit ragged, but the effect is convincing at low magnification. The Lunar X is more complex, being formed when portions of the rims of three intersecting craters (68km La Caille, 118km Purbach and 68km Blanchinus) are illuminated.



The Lunar X (left) and V (right) clair-obscur effects appear near the Moon's terminator

In order to see clair-obscur effects, it's necessary for the Moon's terminator (the line between lunar day and night) to be in a precise position on the lunar surface, the Moon to be above the horizon and for clouds to be absent. In practice, having all three synchronise together isn't as straightforward as you might imagine!

The Lunar X and V can be seen forming just after sunset on 8 February; the effect is at its best around 17:52 UT. Use a low magnification to start and look for the X one-quarter up the terminator from the southern edge. The V appears just north of the Moon's centre on the 8th.

Morning planets: Mars and Venus

BEST TIME TO SEE:
All month

Venus and Mars are visible in the morning sky, not that well placed as seen from the UK as they are in the southern constellation of Sagittarius, the Archer. They form a mismatched couple during the month, Venus shining brightly at mag. –4.5, Mars much dimmer at mag. +1.4. However, they are interesting to watch if you have a flat southeast horizon as they appear to approach one another during the month.

On the 14th, Venus sits 6.5° to the north of Mars, the pair both above the horizon, 90 minutes prior to sunrise. Venus should be obvious, but you'll probably have to wait a little longer for Mars to rise sufficiently to be visible through the low horizon murk. On the 14th, mag. +0.1 Mercury will also be there, forming the sharp point of a sunward-pointing isosceles triangle with Mars and Venus as the base.

On 14 February, look for a grouping of Venus, Mars and Mercury at 06:50 UT (as viewed from the central UK)

A 15%-lit waning crescent Moon sits 4.7° south of Mars on the 27th. On this date, Mars and Venus will appear separated by 5.3°, the Red Planet having brightened to mag. +1.3. By the month's end, both planets appear 5.1° apart, with the separation dropping to just below 4° in the first half of March.

THE PLANETS

Our celestial neighbourhood in February

PICK OF THE MONTH

Uranus

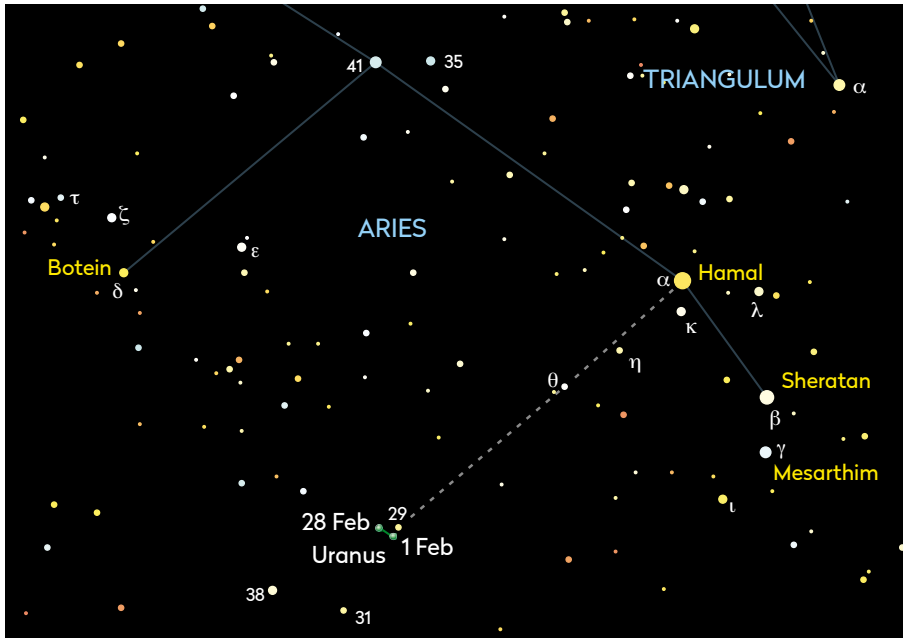
Best time to see: 1 February, 19:00 UT
Altitude: 50°
Location: Aries
Direction: South-southwest
Features: Colour, moons, faint banding visible with larger instruments
Recommended equipment: 150mm or larger

The observational window for Uranus worsens this month, so you might be forgiven for questioning why we've chosen it as the month's best planet. Despite its slowly deteriorating position, it currently has the highest declination of all the main planets, and this means it still maintains a decent altitude after the evening sky darkens. On 1 February, the mag. +5.8 planet appears just west of south as true darkness falls. At this time its altitude is around 50°, way better than any other planet on view from the UK.

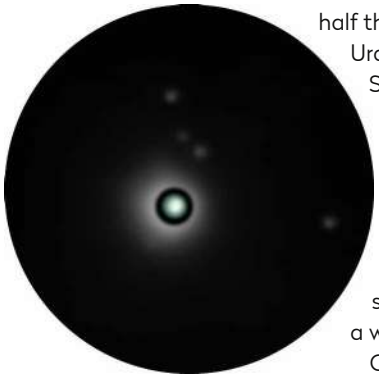
Things do progressively get worse through the month. By the middle of February, Uranus has an altitude of 44° as darkness falls, a figure which drops to 34° by the month's close. Despite the decline, Uranus remains a viable target all month.

A telescope is required to show Uranus as anything more than a star-like dot, and to reveal its green hue. A magnification of 200x or greater will reveal the ice giant's small, but unmistakable disc. Currently, Uranus appears 3.5 arcseconds across. For comparison, Ganymede, the largest of Jupiter's moons and the largest moon in the Solar System, has an apparent diameter of 1.8 arcseconds when Jupiter is near opposition, about half the apparent size of Uranus. Neptune, the Solar System's outer planet, presents a disc 2.2 arcseconds in diameter.

Uranus sits 24 arcminutes south-southeast of 29 Arietis at February's start, the star and planet forming a well-matched visual pair. On 7 February, a 43%-lit waxing crescent Moon sits 1.5° to the south of Uranus (centre-to-centre).



▲ **A view through a telescope will bring out the green hue of Uranus, currently within Aries**

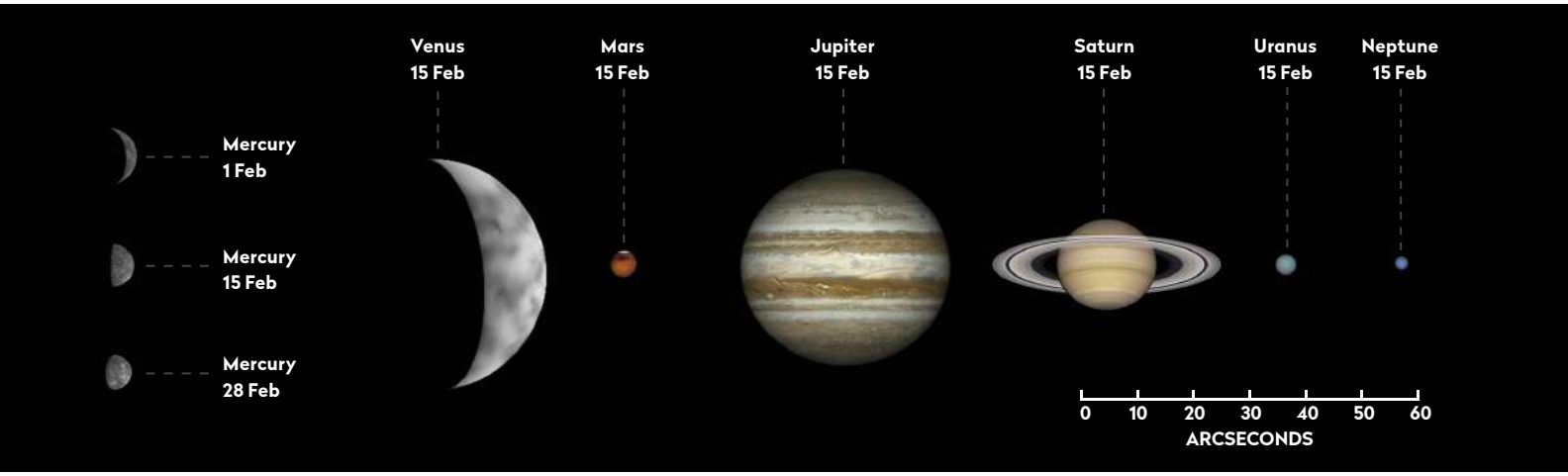


▲ **Uranus and moons: a correctly exposed image is superimposed on an overexposed image**

PETE LAWRENCE X 3

The planets in February

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 1 February, 20 minutes before sunrise
Altitude: 4° (very low)
Location: Sagittarius
Direction: Southeast

Mercury is a morning object, starting the month fairly faint at mag. +1.2 and poorly placed, rising above the southeast horizon 60 minutes before the Sun. That offset is maintained through to greatest western elongation, which is reached on the 16th, when Mercury will have brightened to mag. +0.1.

On its return approach to the Sun, Mercury brightens, while its morning sky position gradually deteriorates.

Venus

Best time to see: 28 February, 40 minutes before sunrise
Altitude: 10°
Location: Sagittarius
Direction: Southeast

Venus is a morning planet, rising two-and-a-quarter hours before the Sun at the month's start, and two hours before the Sun on the 28th. It will appear low above the southeast horizon, shining at mag. –4.5. Mars lies less than 7° south of Venus mid-month, being dimmer at mag. +1.3. On the 27th, Mars lies a little over 5° below Venus under a brighter dawn sky. A 15%-lit waning crescent Moon also sits less than 5° south of Mars.

Through a telescope, Venus appears as a 15%-lit crescent with an apparent disc diameter of 49 arcseconds on the 1st. By the month's end, the phase is 37%-lit and the diameter is 31 arcseconds.

Mars

Best time to see: 28 February, one hour before sunrise
Altitude: 3° (very low)
Location: Sagittarius
Direction: Southeast

Mars rises 110 minutes before the Sun at the start of February, shining at mag. +1.4 in Sagittarius, the Archer. In this part of the sky, Mars never rises to a high altitude before sunrise and this makes it harder to see. The difference in time between sunrise and Mars rising decreases over the month so that by the 28th, it rises 90 minutes before the Sun. Its brightness increases to mag. +1.3, and it will be easier to spot as it sits 5.1° south of mag. –4.5 Venus.

Jupiter

Best time to see: 1 February, 30 minutes after sunset
Altitude: 14° (low)
Location: Aquarius
Direction: Southwest

Shining at mag. –1.9 against the stars of Aquarius, Jupiter is engulfed in the evening twilight. A slender 3%-lit waxing crescent Moon sits below the planet, low above the post sunset west-southwest horizon on the 2nd. The gas giant is lost from view for the month's latter half after its apparent separation from the Sun becomes too small.

Saturn

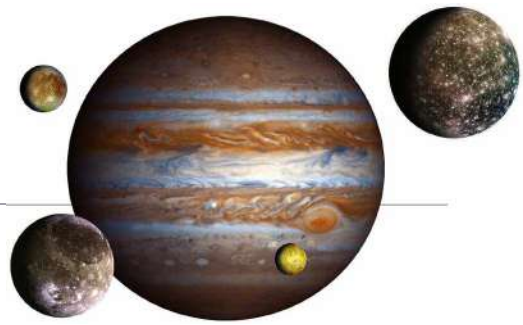
Saturn lines up with the Sun on the 4th and is poorly placed when it re-emerges into the morning sky. It's therefore unlikely to be seen this month.

Neptune

Best time to see: 1 February, 18:50 UT
Altitude: 14°
Location: Aquarius
Direction: West-southwest

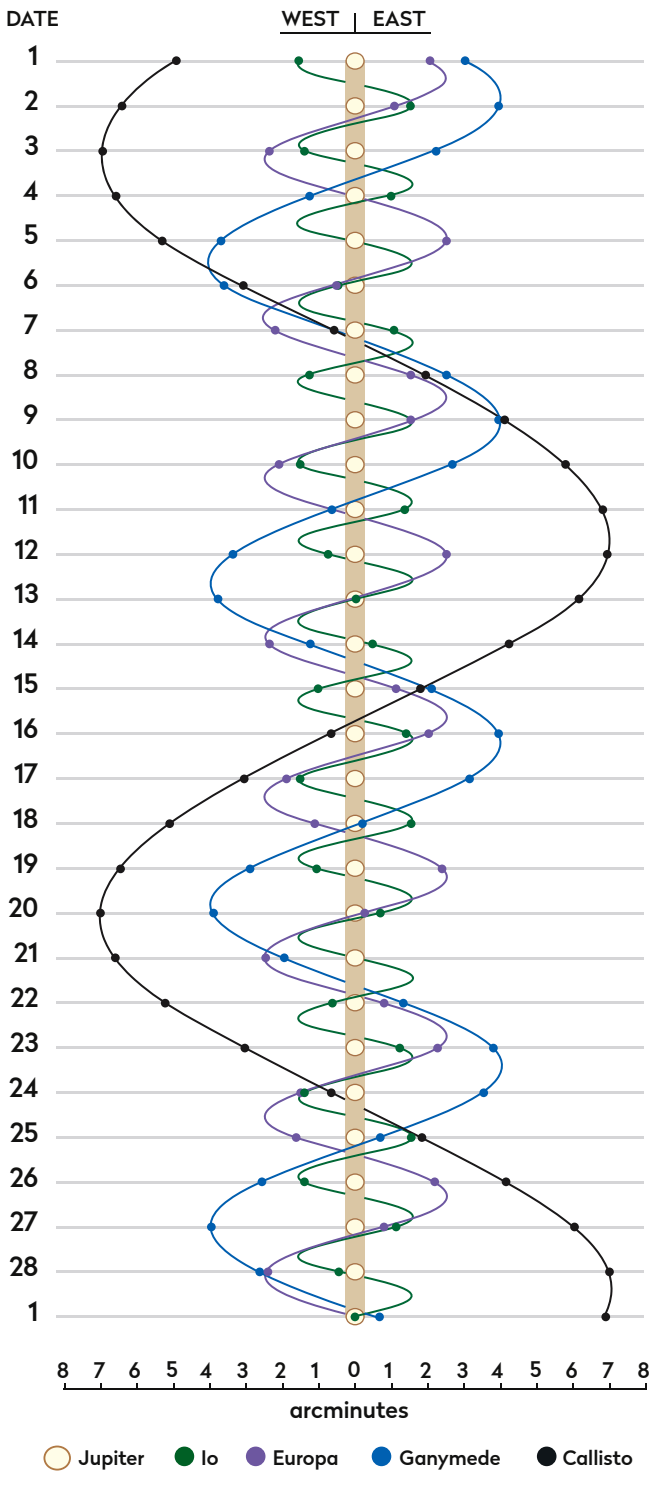
The evening twilight catches up with Neptune this month, the planet unable to maintain a useful altitude in darkness following sunset.

More **ONLINE**
Print out observing forms for recording planetary events



JUPITER'S MOONS: FEBRUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – FEBRUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Cirdet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

CHART: PETE LAWRENCE

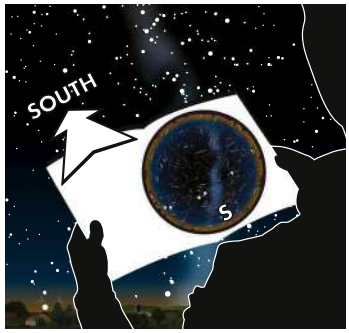
When to use this chart

1 February at 00:00 UT
15 February at 23:00 UT
28 February at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in February*

Date	Sunrise	Sunset
1 Feb 2022	07:55 UT	16:53 UT
11 Feb 2022	07:37 UT	17:13 UT
21 Feb 2022	07:16 UT	17:32 UT
3 Mar 2022	06:53 UT	17:52 UT

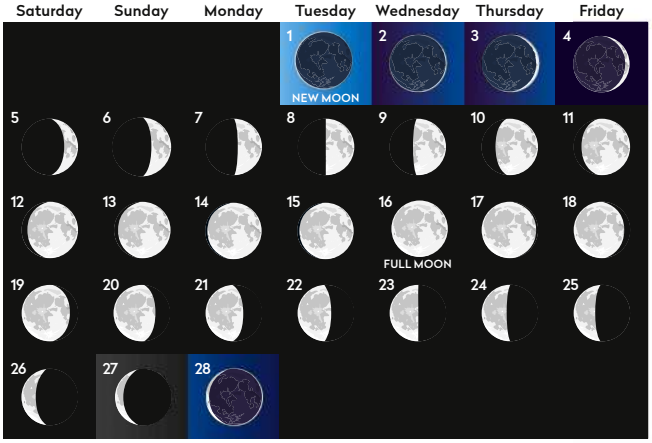
Moonrise in February*

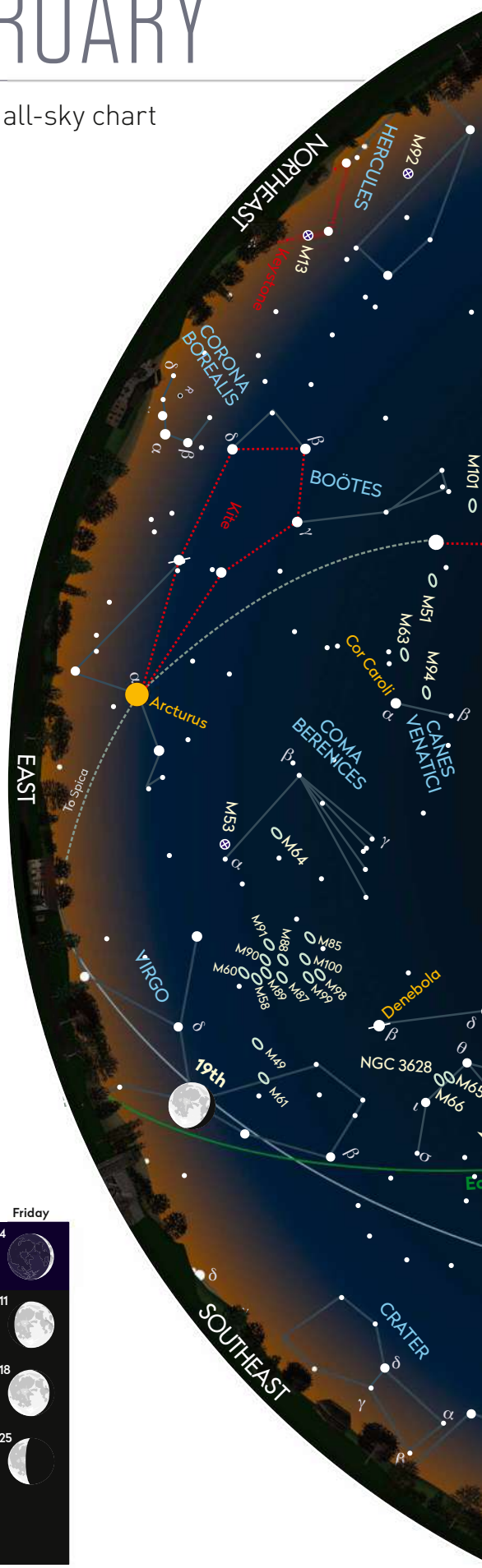
Moonrise times

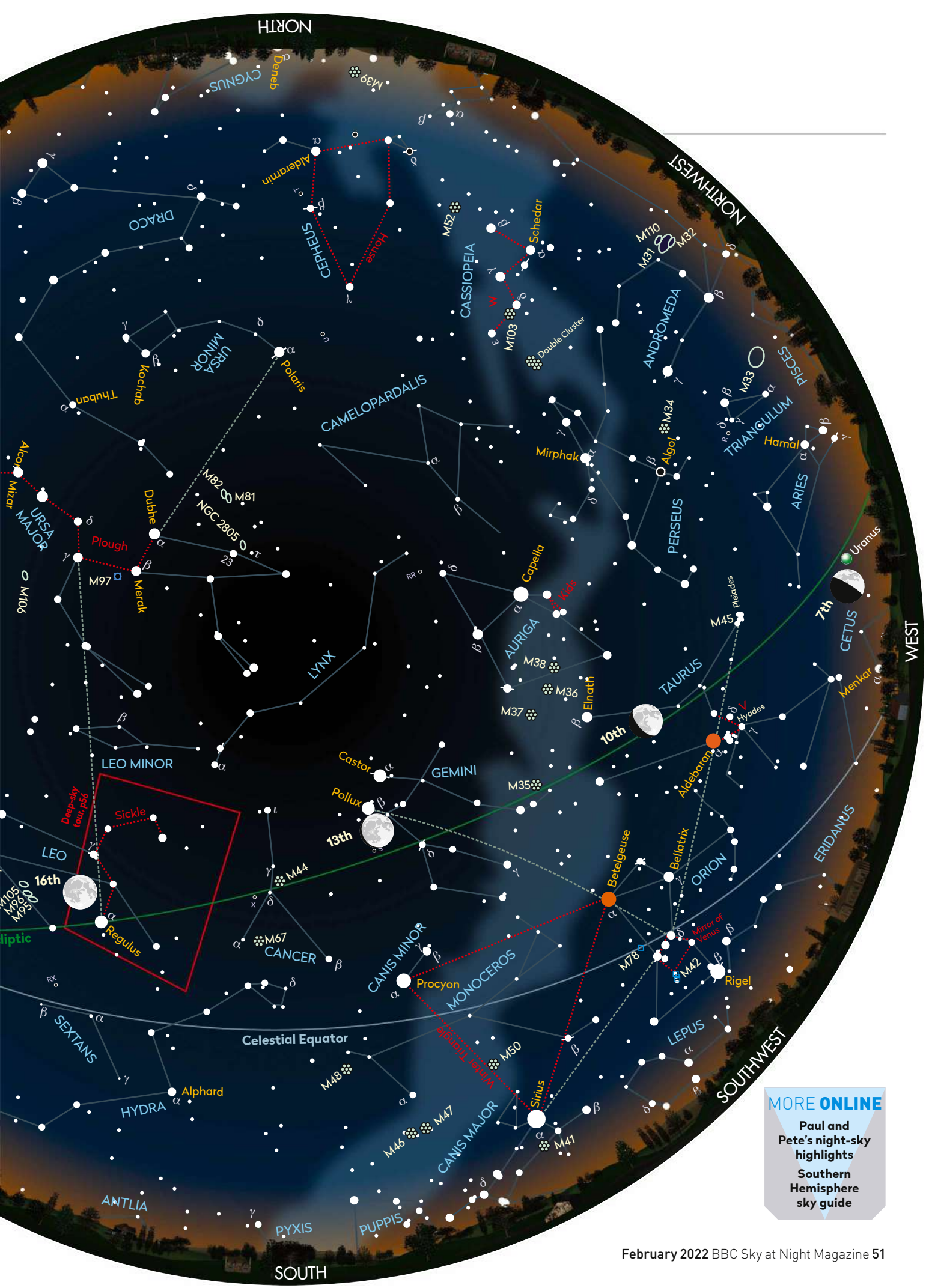
1 Feb 2022, 08:44 UT	17 Feb 2022, 18:15 UT
5 Feb 2022, 09:49 UT	21 Feb 2022, 23:40 UT
9 Feb 2022, 10:44 UT	25 Feb 2022, 03:59 UT
13 Feb 2022, 13:16 UT	1 Mar 2022, 07:09 UT

*Times correct for the centre of the UK

Lunar phases in February







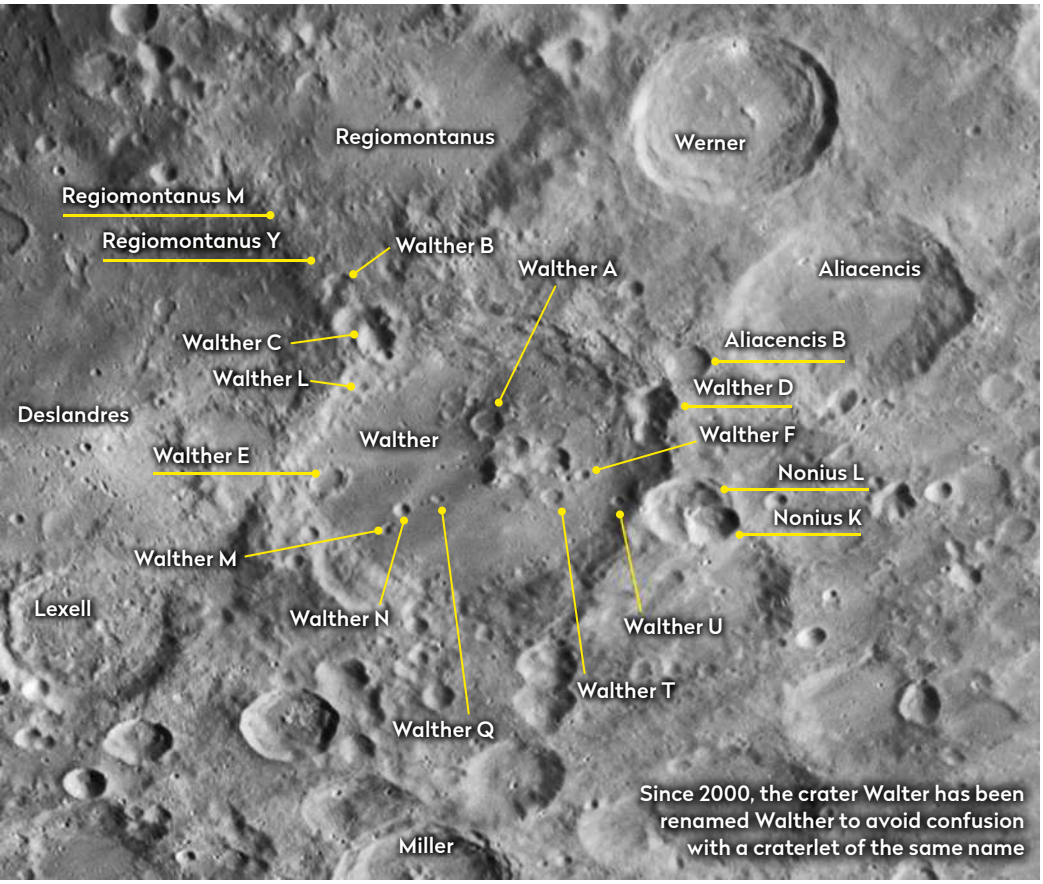
MORE **ONLINE**

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH

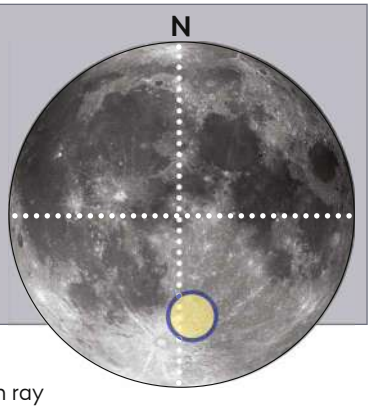
February's top lunar feature to observe



PETE LAWRENCE X 3

Walther

Type: Crater
Size: 141km
Longitude/Latitude: 0.6° E, 33.2° S
Age: Approximately 3.9 billion years
Best time to see: First quarter (8-9 February) or six days after full Moon (22-23 February)
Minimum equipment: 10x binoculars



Walther is a large, rugged crater located 440km northeast of the prominent 86km ray crater Tycho. It sits within the complex, highly cratered southern region of the Moon and takes a bit of navigational finding despite its size.

Walther sits adjacent to the large walled plane of 235km **Deslandres** extending to the west. From the centre of Walther, 75km **Miller** lies 200km to the south and 70km **Werner** lies 174km to the northeast. Werner sits near the trio of craters, 118km Purbach, 68km Blanchinus and 68km La Caille. These are components of the popular Lunar X clair-obscur effect, which is visible around first-quarter phase.

Walther's ancient rim shows complexity, which is most apparent under oblique lighting. Multiple terraces have become smoothed and rounded over time, but still retain their underlying structure.

Various peaks appear around the rim, one to the east rising to a height of 3km. This casts an impressive shadow when the morning terminator approaches in the run up to first-quarter. The rim has been subject to a large number of impacts and these look incredible under oblique lighting, giving the rim sections a complex texture in which it's easy to get lost. This is especially true to the north where Walther borders 126km **Regiomontanus**.

Apart from the northeast quadrant, most of the inner floor appears smooth, save for an interruption from 13km **Walther E** to the west, and the trio of **Walther N** (6km), **Walther M** (5km) and **Walther Q** (4km) in the southwest. The central mountain is around 2km high. It's more-or-less central on the north-south axis, but definitely offset east. The asymmetry is accentuated by the presence of rough terrain to the northeast and includes the craterlets **Walther A** (12km) to the north of the central mountain, together with **Walther T** (8km) and **Walther F** (6km) to the east.

Walther's outline stands up well, considering the erosive pounding that its rim sections have taken over time. A curious intrusion occurs in the northwest, where a progression of overlapping craters – arranged radially from Walther's centre – appear to break through the rim. This line includes 14km **Walther C**, 9km **Walther B**, 5km **Regiomontanus Y** and 5km **Regiomontanus M**.

A more noticable breach occurs to the east. The northeast rim section is interrupted by 18km **Walther D** while the eastern section is more demonstrably breached by 31km **Nonius L**, itself overlaid southeast by 18km **Nonius K**. As a test of resolution for a 200mm telescope, see whether you can spot the tiny 4km craterlet **Walther U**, which lies on the floor of Walther immediately west of Nonius L.

Walther used to be called Walter until it was realised that there were two craters with the same name. The other Walter is a tiny 1.2km craterlet in the western part of Mare Imbrium. Apparently, the duplication had existed for 20 years before anyone noticed. The renaming of Walter to Walther was contentious and a number of amateurs and professionals still use the old name today.

Walther's terraces have become rounded, but still retain their underlying structure

COMETS AND ASTEROIDS

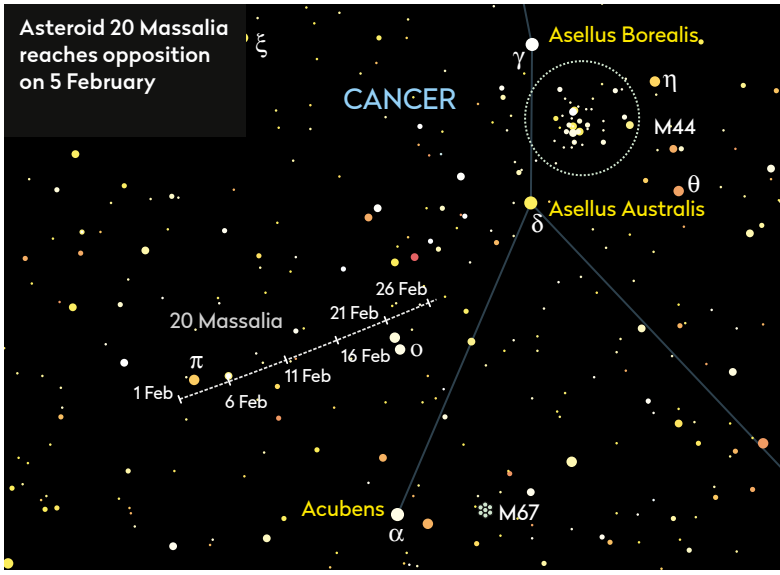
Asteroid 20 Massalia is a good target with a small telescope through the month

Asteroid 20 Massalia reaches opposition this month in Cancer, the Crab. It's located near to the border of Cancer and Leo, the Lion on the 1st, 5° east-northeast of mag. +4.3 Acubens (Alpha (α) Cancri). It then tracks west-northwest along a line that takes it to a point about 4° southeast of mag. +3.9 Delta (δ) Cancri.

Massalia has an orbit that keeps it within the inner part of the main asteroid belt. It's the parent body of a large group of asteroids known as the Massalia family, a collection which has over 6,000 members. Massalia is an S-type, or stony asteroid, with a mean diameter of 145km. Its orbital period is 3 years 9 months and its mean distance from the Sun is 2.41 AU (361 million kilometres). When at aphelion, its orbit takes it out as far as 2.75 AU from the Sun, and when at perihelion it moves in as close as 2.07 AU. Massalia is believed to be nearly spherical in shape, having triaxial ellipsoidal dimensions of 160x145x132km. It is also believed to have large, flat regions on its surface. Its rotation period is 8.1 hours.

Massalia's geometric albedo is 21%, a figure that indicates how much incoming sunlight is reflected back from the asteroid's surface. This leads to an apparent magnitude that ranges from +8.3 at favourable oppositions to mag. +12.0 at its least favourable oppositions. This month is favourable, Massalia reaching opposition on the 5th when it appears to shine at mag. +8.5.

On 1 February, Massalia is mag. +8.7, brightening by one-fifth of a magnitude as it reaches opposition. By the month's end it will have dimmed to mag. +9.3.



STAR OF THE MONTH

Discover Mirzam, Canis Major's 'herald'

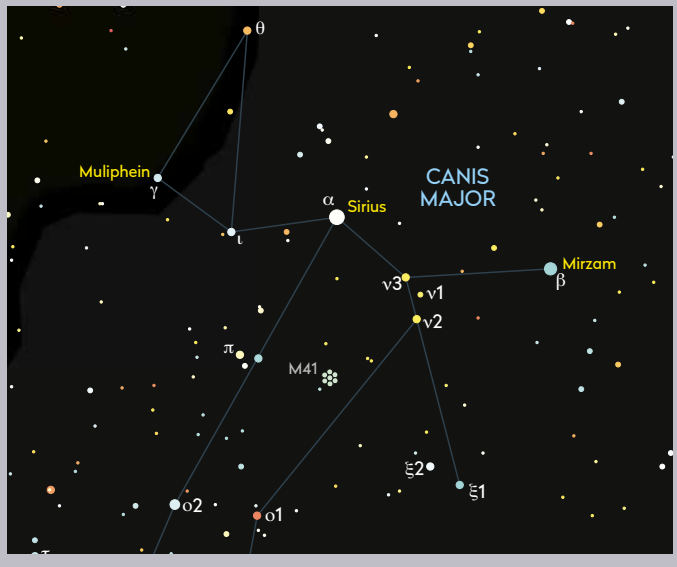
Although Mirzam (Beta (β) Canis Majoris), shines at mag. +2.0, it's outshone by its sky neighbour, mag. –1.5 Sirius (Alpha (α) Canis Majoris).

Mirzam lies 5.5° west and a bit south of Sirius and is easy to identify for this reason. Its name is derived from the Arabic term meaning 'The Herald', thought to refer to the fact that it rises just before Sirius, so heralding or announcing the appearance of its neighbour. Mirzam is the fourth brightest star in Canis Major, the Great Dog.

Sirius may appear to dominate over Mirzam in terms of brightness, but the pair are an example of how the apparent sky we see is deceptive. Sirius is located 8.7 lightyears away from the Sun. Mirzam is a more distant star, estimated to be 490 lightyears away. Although Sirius appears to be 24 times brighter to us in the sky, Mirzam is 56 times further away. If you were to place them at a standard distance of 10 parsecs, or 32.62 lightyears, Sirius would have an absolute magnitude of +1.4 while Mirzam would appear at mag. –4.1, similar to how bright Venus appears from Earth. If you were to place Mirzam at the distance of Sirius, it would shine 15 times brighter than Venus appears to us!

Mirzam has a spectral type of B1 II-III, a hot, blue, bright giant star. Its temperature has been measured at 25,527°C, which means that a lot of its radiative output is in the spectrum's ultraviolet part. By comparison, it's 14 times more massive, 10 times larger and has a luminosity around 26,600 times larger than the Sun. Its also variable, the brightest member of the Beta Cephei class of variables.

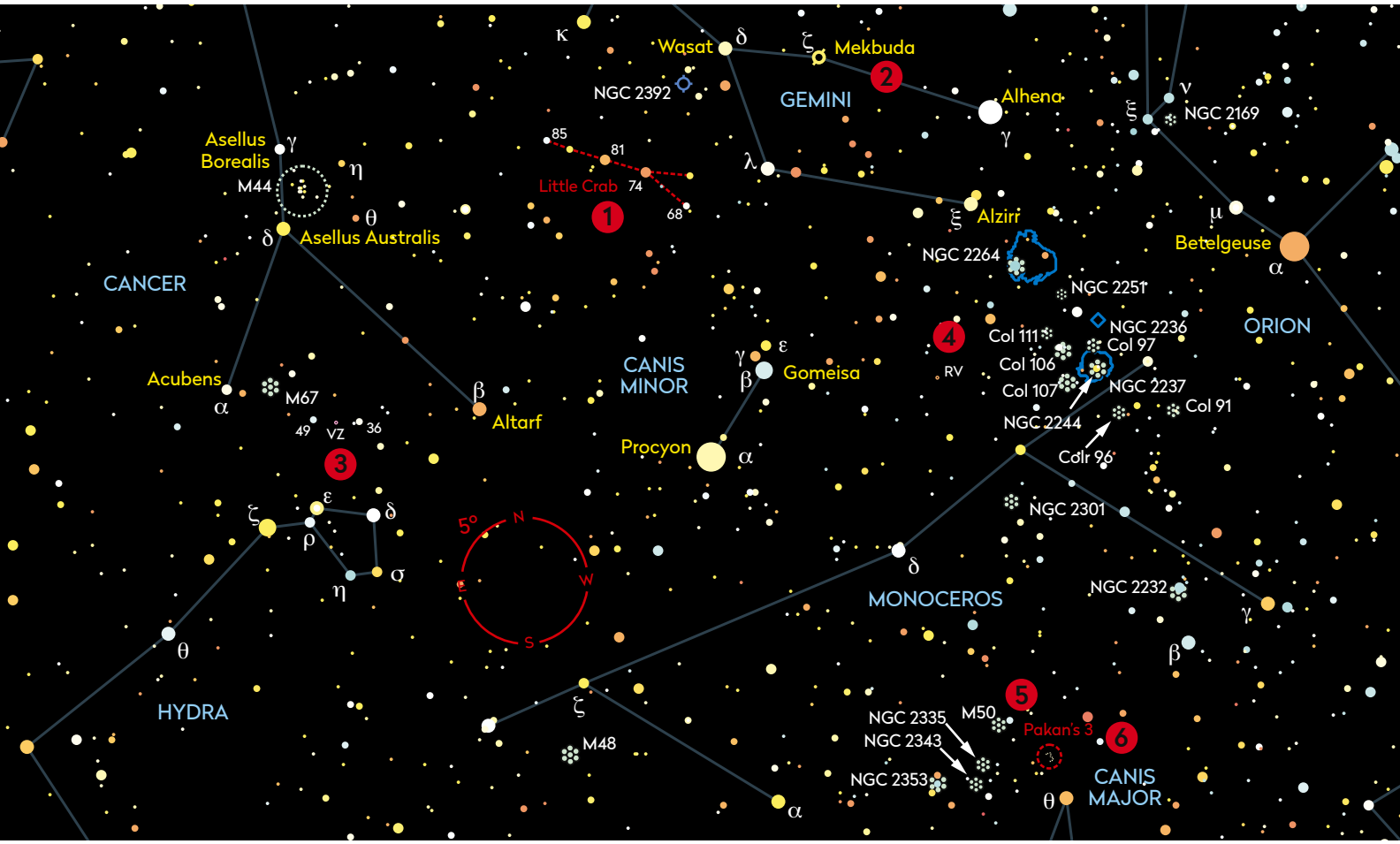
▼ **Look for the blue-white star Mirzam, west and south of bright Sirius**



BINOCULAR TOUR

With Steve Tonkin

This month's highlights include the Little Crab, a former 16th-century constellation



PETE LAWRENCE X 3

1. The Little Crab

10x 50 The 48 Greek constellations had gaps between them, and some of these were filled with new constellations. For a few decades in the 16th century, Cancer Minor, proposed by Flemish astronomer Petrus Plancius, was one of these. This asterism of different coloured 5th magnitude stars extends 7° from 85 Geminorum to 68 Geminorum, looking like a fainter version of Sagitta. It's 6° south of Kappa (κ) Geminorum. ☐ **SEEN IT**

2. Mekbuda

10x 50 Mekbuda (Zeta (ζ) Geminorum) is a Cepheid variable (mag. +3.6 to +4.2) star. The period of a Cepheid is proportional to its luminosity (intrinsic brightness) so, merely by measuring its period, you can determine its distance by comparing its luminosity with magnitude. Mekbuda's period is 10.15 days, so you can obtain a light curve in a month. It is an easy, wide double star. ☐ **SEEN IT**

3. VZ Cancri

10x 50 If 10.15 days is too long for you and you want to watch a star complete its cycle of variability in a single session, this is the one for you! VZ Cancri oscillates between mag. +7.2 and +7.9 over a period of 4 hours 17 minutes. You'll find it midway between 49 and 36 Cancri. VZ is a RR Lyrae variable; it has a rapid rise in brightness followed by a dimming. ☐ **SEEN IT**

4. RV Monocerotis

10x 50 RV Monocerotis is an altogether different experience. This red giant star takes 121.3 days to cycle through magnitudes +6.9 and +7.7. It is classified as a semi-regular variable owing to its underlying periods of 91.8 and 1047 days. There are no bright markers nearby, so find it by taking a line from Alhena (Gamma (γ) Geminorum) through Xi (ξ) Geminorum and extending it a further 7.5° – RV is the reddest star in the field of view. ☐ **SEEN IT**

5. M50

10x 50 M50 lies 8° from Delta (δ) Monocerotis in the direction of Theta (θ) Canis Majoris. Expect to see a circular glow about half the Moon's apparent diameter. This comes from just over 100 stars, but you won't be able to resolve more than four or five, depending on the sky's darkness, in 10x50 binoculars. ☐ **SEEN IT**

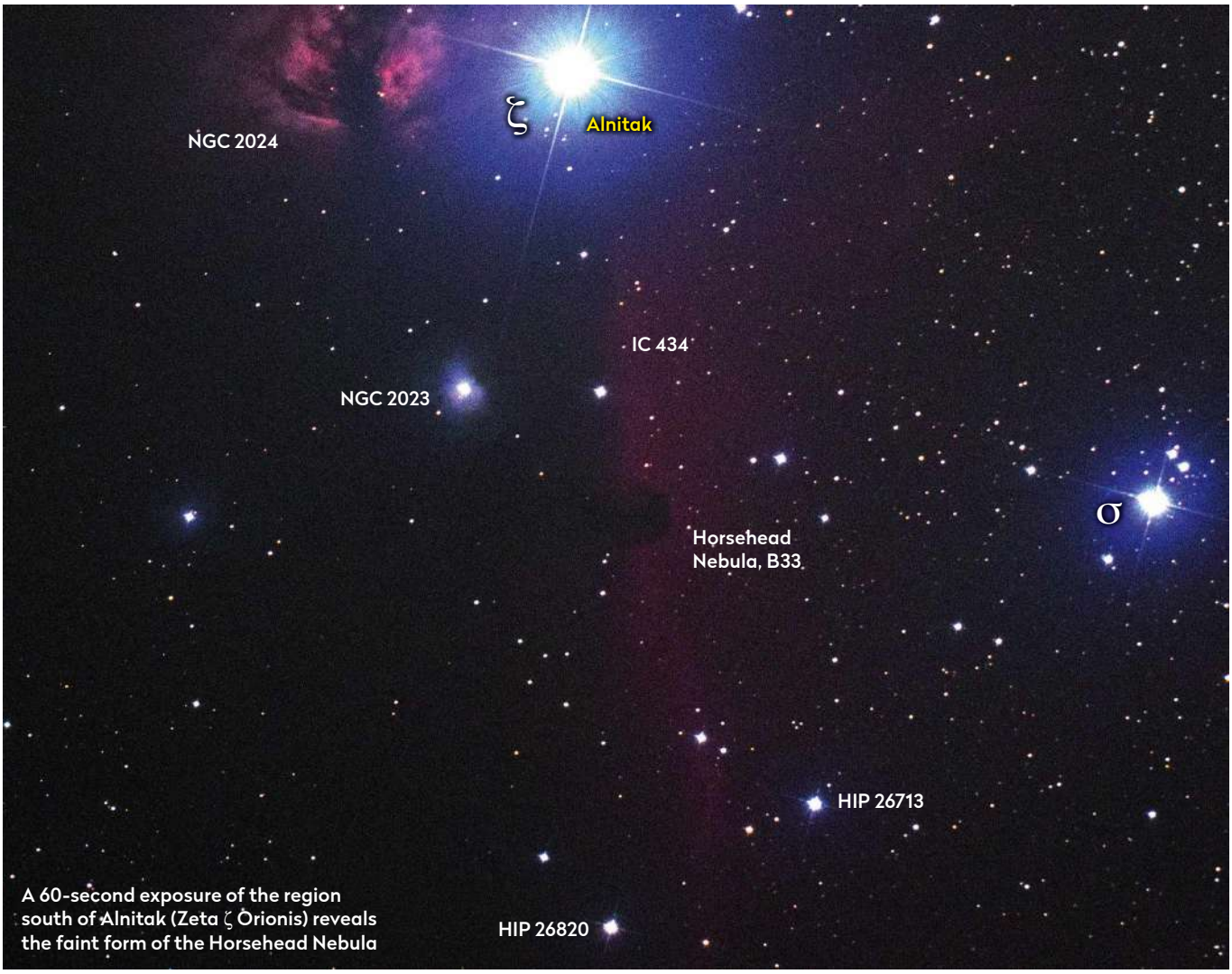
6. Pakan's 3

15x 70 This little asterism is 3° southwest of M50 and 2° north of Theta (θ) Canis Majoris. As long as you have a dark transparent sky, the number '3', which is composed from 11 (9th magnitude) stars, stands out from the background Milky Way. Spend a bit of time on it with mounted binoculars, when the colours of the stars, ranging from white to orange, become more perceptible. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Can you locate and capture the Horsehead Nebula with a camera or a smartphone?



A 60-second exposure of the region south of Alnitak (Zeta ζ Orionis) reveals the faint form of the Horsehead Nebula

Orion, the Hunter remains prominent through February and this is a great time to try for what used to be regarded as a difficult photographic target, the Horsehead Nebula, B33. In modern times, highly sensitive camera sensors have made it less tricky and if you've never attempted it before, this is a great time to try. If you have captured it in the past, we've got an extended challenge for you too.

The Horsehead is a dark nebula, a protrusion of gas which creates a silhouette in front of a glowing curtain of emission nebula IC 434. The curtain runs south of Alnitak (Zeta (ζ) Orionis). From Alnitak, locate mag. +3.8 Sigma (σ) Orionis 0.8° to the southwest. Now look 0.5° to the east-southeast where you'll find mag. +6.2 HIP 26713 with mag. +6.4 HIP 26820, 0.3° further to the east. Both faint stars are distinctive in the region and identifiable. IC434 runs from just south of Alnitak towards HIP 26820. The Horsehead is midway between Alnitak and HIP 26820.

In order to capture it you'll need a camera set up on an equatorial, polar-aligned, tracking mount. This could be a camera on its own or one attached to a telescope. A field of view of at least 2° is recommended. Using a full-frame DSLR camera requires a focal length of less than 1,000mm, while a camera with an APS-C sensor requires a focal length of less than 600mm.

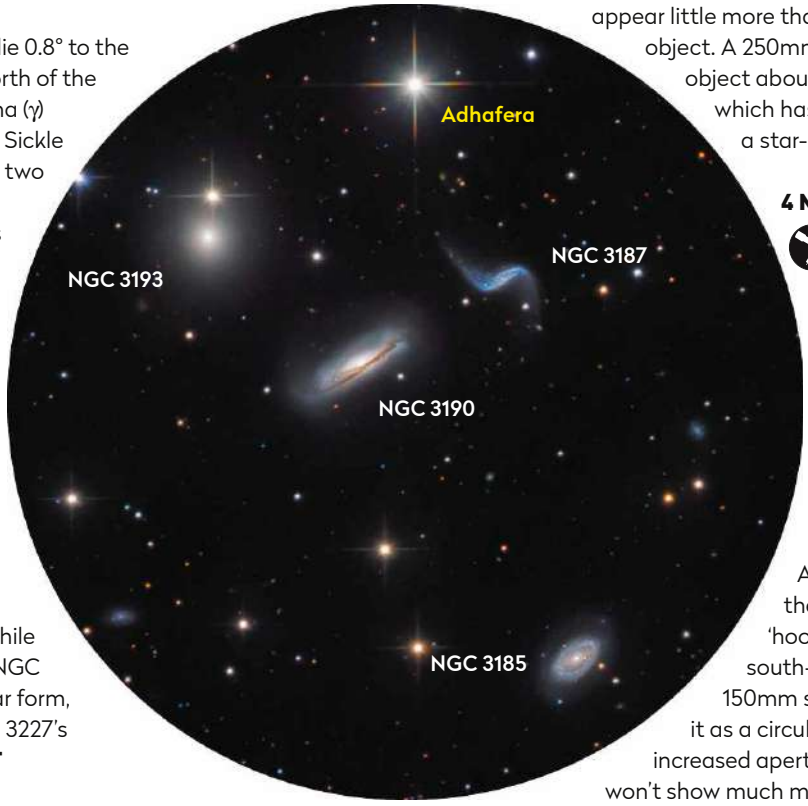
Focus accurately and frame your shot to include both Alnitak and HIP 26820. Set your camera to a mid-range ISO and take as long an exposure as your mount will allow without star trailing. If you're not sure what this limit is, use the 'bracket exposure' technique, where you take a series of test shots – with exposures of 30 seconds, 60 seconds and 90 seconds etc – until you see signs that the stars are starting to trail.

Taking multiple shots along with dark frames etc, will allow you to produce a better result, but if you're impatient and want to see what's there, load your longest exposure into a graphics editor, open adjustment levels and move the two extreme markers so they sit at the data peak's start and end. If successful, the Horsehead silhouette will become obvious. The next step is to improve on the result.

If you're an old hand at imaging the Horsehead with a camera, you could try the further challenge of capturing it with a smartphone. It's possible with a bright object such as M42, but the Horsehead may be beyond this method of capture.

DEEP-SKY TOUR

Take a look at fascinating objects near the Sickle asterism in Leo, the Lion



▲ **Near the star Adhafera (Zeta (ζ) Leonis) you will find a host of multiple galaxies with a telescope, with the edge-on spiral NGC 3190 being the easiest to spot**

THOMAS HENNE/CCDGUIDE.COM, CHART BY PETE LAWRENCE

1 NGC 3226/3227

Our first targets lie 0.8° to the east and a bit north of the double star Algieba (Gamma (γ) Leonis), which is part of the Sickle asterim. Here you'll find the two interacting galaxies, NGC 3226 and 3227. NGC 3226 is a dwarf elliptical galaxy that shines with an integrated magnitude of +11.4. NGC 3227 is brighter at mag. +10.8 and is a spiral galaxy with an active nucleus that has been identified as a variable X-ray source. Both galaxies can be seen as faint, indeterminate smudges through a 150mm scope, while a 250mm scope will show NGC 3226 to have a more circular form, situated northwest of NGC 3227's elongated core. ☐ **SEEN IT**

2 NGC 3193/3190

Our next target consists of multiple galaxies too. Located midway between Algieba and Adhafera (Zeta (ζ) Leonis), you'll find, in order of brightness, NGC 3193, 3190, 3185 and 3187. NGC 3193 and 3190 have magnitudes of +10.9 and +11.0 respectively. Edge-on spiral NGC 3190 is the easiest of the four to see. NGC 3193 is an elliptical and together with 3190 can be seen using a 150mm scope. NGC 3185 is a mag. +12.2 face-on barred spiral requiring at least 200mm of aperture. NGC 3187 is a mag. +13.1 barred spiral, but it appears faint and it will give even a 300mm scope a run for its money. The four galaxies are gravitationally bound, forming a group catalogued as Hickson 44. ☐ **SEEN IT**

3 NGC 3162

Centre your telescope on mag. +3.4 Adhafera and slew 1° to the southwest to point at our next target, spiral galaxy NGC 3162. Listed at mag. +11.6, NGC 3162 is large, its total size approaching 3 arcminutes across. It's a distorted face-on galaxy which has a low surface brightness. A 150mm scope will just about show it, but it will appear little more than a large, faint 'ghost-like' object. A 250mm telescope shows an object about 80 arcseconds across, which has a well-defined core with a star-like nucleus. ☐ **SEEN IT**

4 NGC 2916

We head further west for our next target, a 12th magnitude spiral galaxy with an active nucleus catalogued as NGC 2916. The best way to locate it is to identify mag. +4.3 Alterf (Lambda (λ) Leonis). Alterf lies 3.2° west and 0.7° south of Algenubi (Epsilon (ε) Leonis), the last star in the Sickle's 'hook'. NGC 2916 sits 1.4° south-southeast of Alterf. A 150mm scope will just about show it as a circular glow and although increased aperture helps, a 250mm scope won't show much more than a brighter, elongated glow. A 300mm scope shows the galaxy's stellar core and hints at mottling across its misty appearance. ☐ **SEEN IT**

5 NGC 2903

Our next target is a beauty. NGC 2903 is a bright, barred-spiral galaxy located 40 arcminutes west-southwest of NGC 2916 or, 1.5° due south and a fraction to the east of Alterf. It shines with an integrated magnitude of +8.9 and is easy to see with a 150mm scope. Such an instrument reveals an object 8x4 arcminutes in size and shows an unevenly lit core. A 250mm scope picks out what appears to be the galaxy's star-like nucleus well. A 300mm instrument shows this core to be extending, measuring 0.5x0.3 arcminutes. With such an instrument, the mottled outer halo appears brightest and easiest to see on the western side. ☐ **SEEN IT**

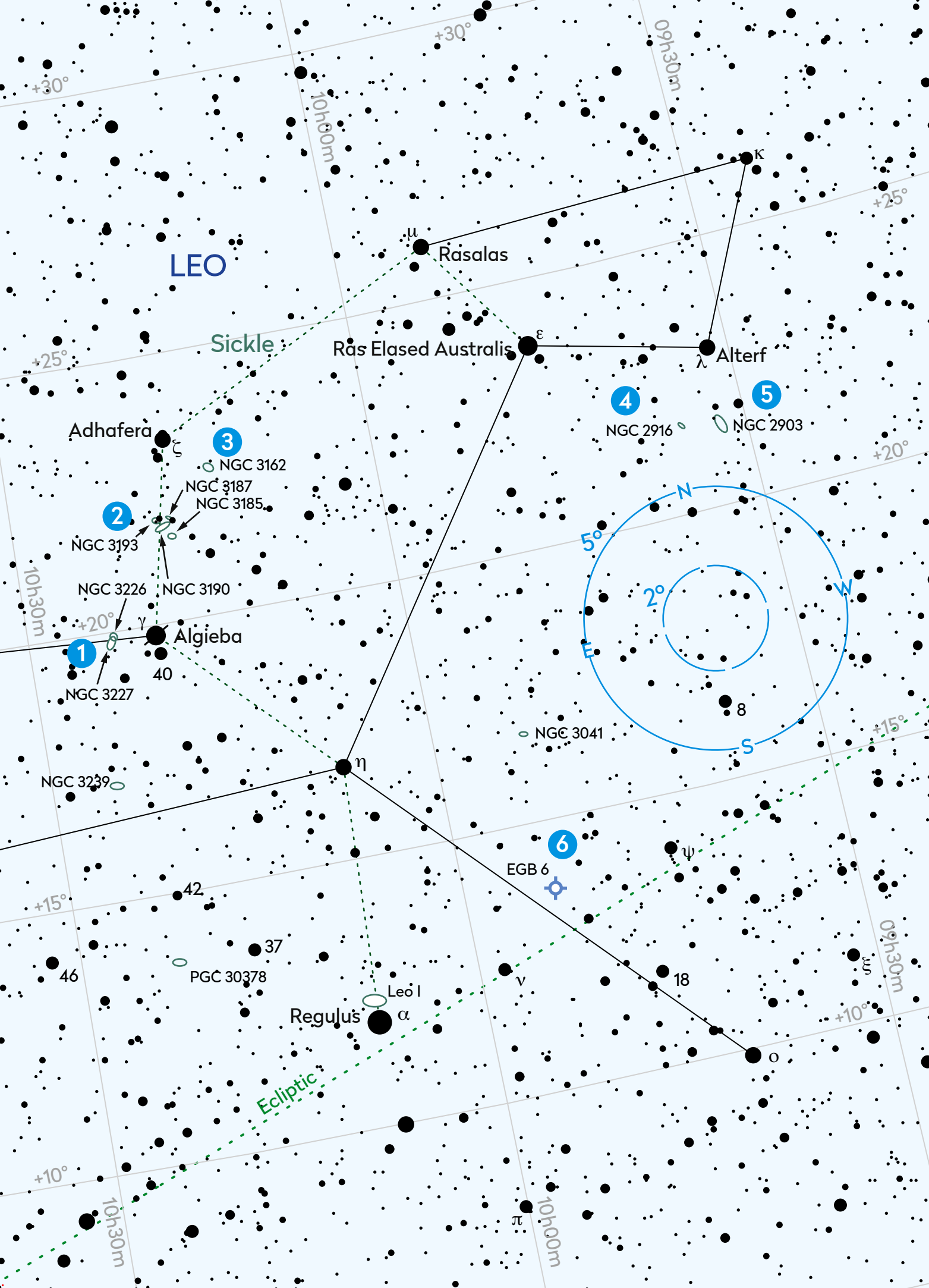
6 EGB 6

Our last target is a challenge. Ellis 6 also known as EGB (Ellis-Grayson-Bond) 6 is a faint planetary nebula near Regulus (Alpha (α) Leonis). It sits 4.1° west-northwest of Regulus, or for a better guide, imagine the mid-point of a line between Eta (ε) Leonis and Omicron (ο) Leonis. EGB 6 lies 0.3° west-northwest of this point. It's listed as mag. +10.3, but because it's large with a diameter around 12 arcminutes, it has a low surface brightness. A 200mm instrument can show it, but you'll need to use averted vision along with an OIII (Oxygen III) filter. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.


LEO
Sickle
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NGC 2903
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EGB 6
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+30°
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+20°
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+10°
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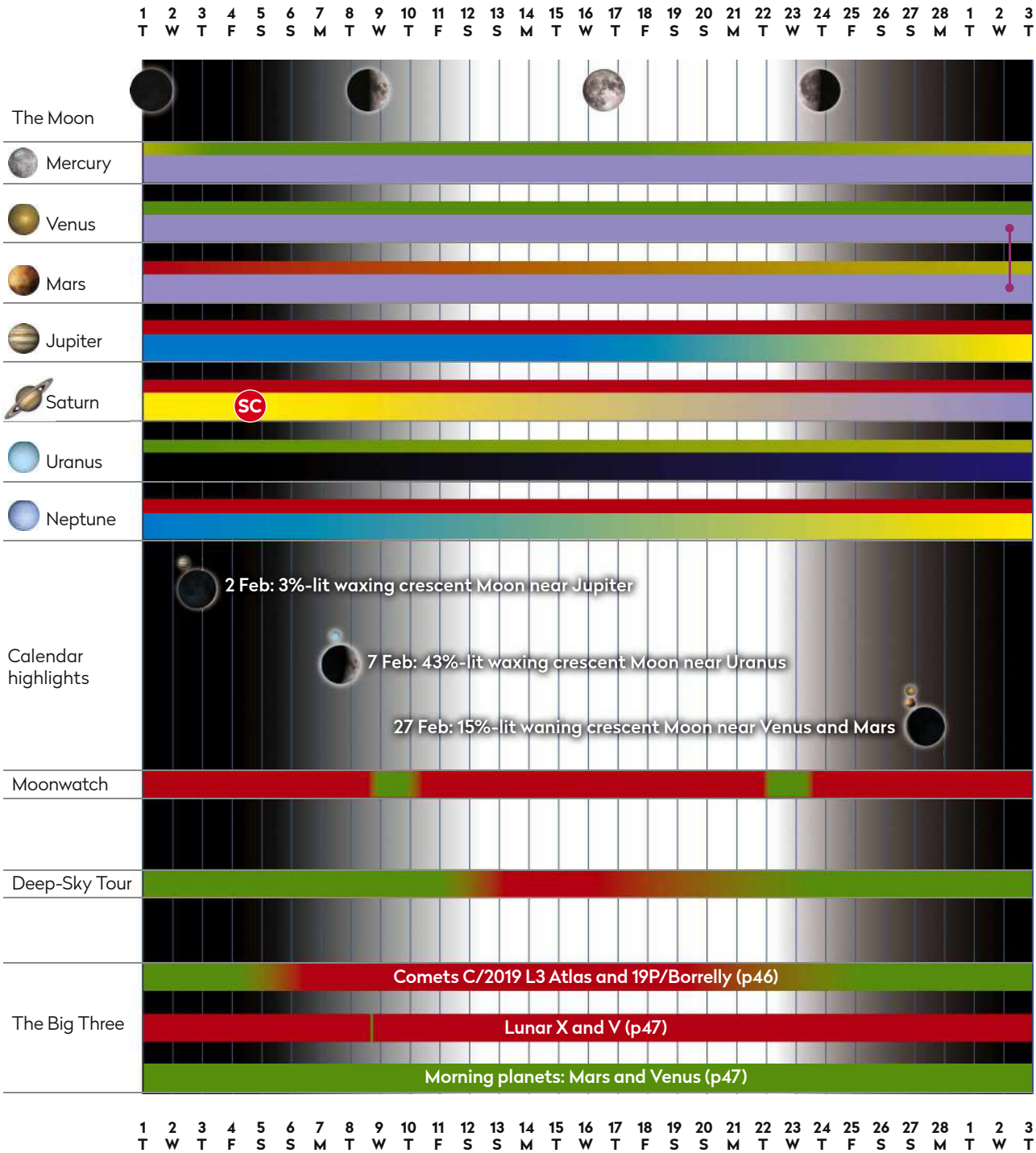
10h00m
10h30m

AT A GLANCE

How the Sky Guide events will appear in February


1 T 2 W 3 T 4 F 5 S 6 S 7 M 8 T 9 W 10 T 11 F 12 S 13 S 14 M 15 T 16 W 17 T 18 F 19 S 20 S 21 M 22 T 23 W 24 T 25 F 26 S 27 S 28 M 1 T 2 W 3 T
The Moon
Mercury
Venus
Mars
Jupiter
Saturn
SC
Uranus
Neptune
Calendar highlights
2 Feb: 3%-lit waxing crescent Moon near Jupiter
7 Feb: 43%-lit waxing crescent Moon near Uranus
27 Feb: 15%-lit waning crescent Moon near Venus and Mars
Moonwatch
Deep-Sky Tour
The Big Three
Comets C/2019 L3 Atlas and 19P/Borrelly (p46)
Lunar X and V (p47)
Morning planets: Mars and Venus (p47)
1 T 2 W 3 T 4 F 5 S 6 S 7 M 8 T 9 W 10 T 11 F 12 S 13 S 14 M 15 T 16 W 17 T 18 F 19 S 20 S 21 M 22 T 23 W 24 T 25 F 26 S 27 S 28 M 1 T 2 W 3 T

KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

- IC — Inferior conjunction (Mercury & Venus only)
- SC — Superior conjunction
- OP — Planet at opposition
- Meteor radiant peak
- Planets in conjunction

- Full Moon
- First quarter
- Last quarter
- New Moon

CHART BY PETE LAWRENCE

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'Maria Mitchell, the Danish comet medal & early American astronomy'

MARTIN LEWIS
'Imaging the nightside of Venus'

CALLUM POTTER
Sky notes for April

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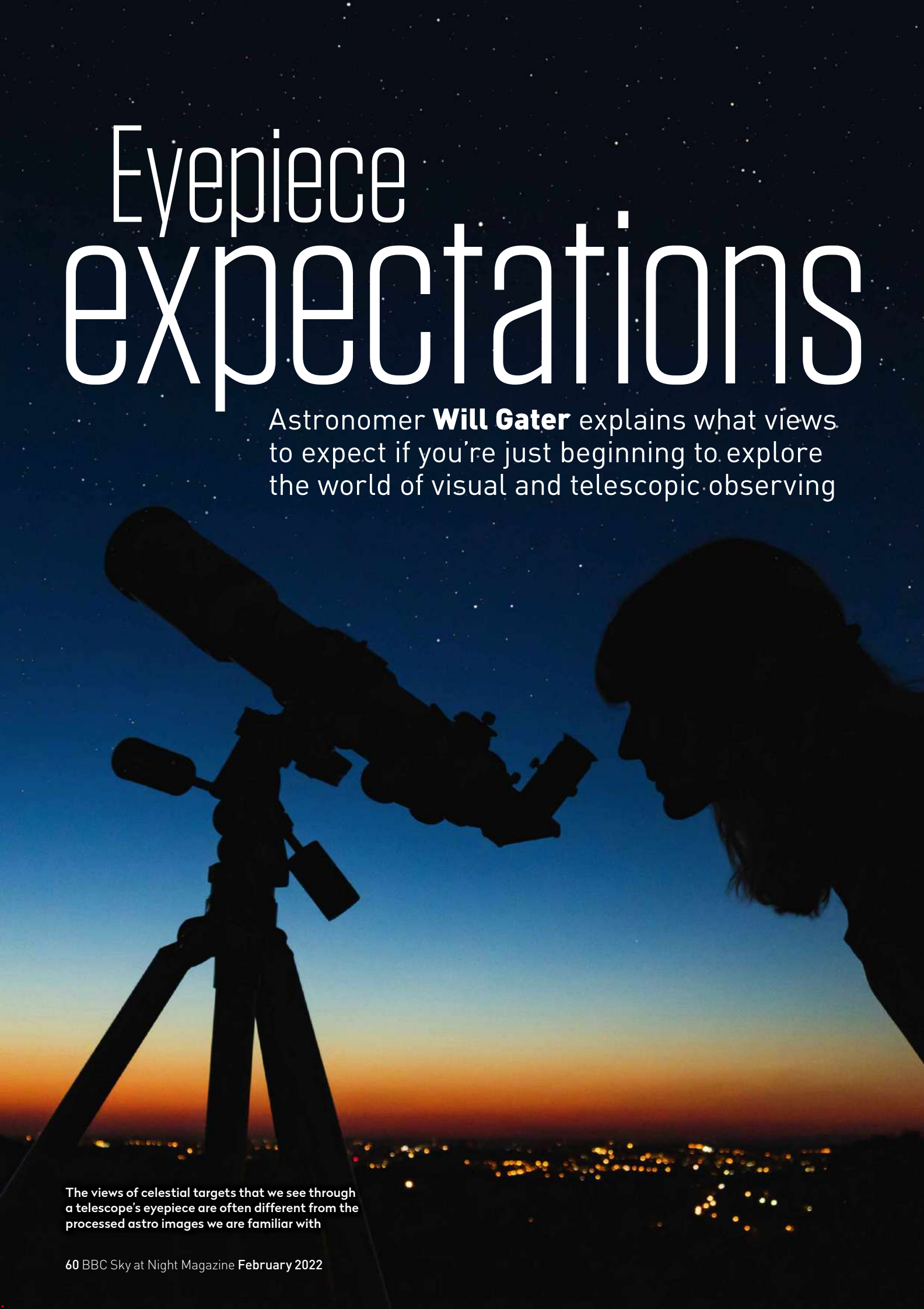
Image: Terry Evans

Eyepiece expectations

Astronomer **Will Gater** explains what views to expect if you're just beginning to explore the world of visual and telescopic observing



The views of celestial targets that we see through a telescope's eyepiece are often different from the processed astro images we are familiar with

There's a key moment in stargazing, after you've set up your kit and honed in on a target, when you first lean in to the eyepiece to take in the view. For experienced observers this can be the point where you set eyes on an old celestial friend, but for beginners it can be a challenge to expectations – when the glittery renditions of astronomical objects viewed online and in print meet the reality of a view through an actual instrument.

This difference between the visual appearance of celestial phenomena and astrophotos, even when using fairly large aperture telescopes, is probably one of the biggest learning experiences for anyone starting out. This month, we're exploring a selection of night-sky sights to give newcomers an idea of what to expect when you glimpse them for the first time. None of this means visual observing is any less interesting; we hope, instead, that our descriptions here will help inspire a sense of reality to ensure those early observing memories are full of wonder.

Will Gater is an astronomy journalist and science presenter. His latest book, *The Mysteries of the Universe*, is published by DK

An astrophoto of the Milky Way (left) compared to a typical naked eye view from a dark sky site (right)

The Milky Way and its star fields

The soft light of our Galaxy weaves a subtle band across the sky

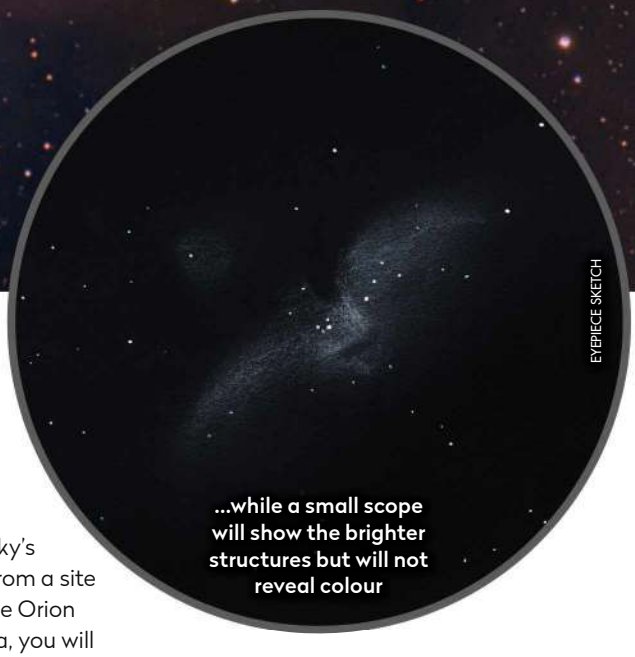
A view of the misty light of our Galaxy from a dark-sky site can be one of the most profound and awe-inspiring sights for any beginner to stargazing, especially in the UK summer months when part of the core of the Milky Way sits over the southern horizon. But it's also one astronomical sight where there's a stark difference between highly processed pictures and how it actually looks to the eye, even under dark skies. Nightscape astrophotography containing the Milky Way often shows a billowing band of bright, almost dazzling, light stretching across the sky, sometimes accompanied by prominent flourishes of colour where glowing star-forming nebulae sit. However, to the naked-eye under a suburban sky, even perceiving the soft light of our Galaxy can be challenging, since even a modest amount of background light pollution is enough to hide its faint glow.

On nights when the air is particularly clear, when the atmospheric 'transparency' is excellent, it's certainly possible to see the brighter patches of Milky Way star fields – such as those that sit in Cygnus or Scutum – from suburban areas. Under these conditions the Galaxy's star fields tend to appear as diffuse swathes of light sitting within the overall suburban skyglow, and they're subtle enough that they can sometimes be confused with patches of thin cloud.

To get a sense of the Milky Way as an obvious band of light across the sky requires somewhat darker locations. Under the inkiest-black skies the band of the Galaxy still appears as a greyish glow, but the soft forms of its numerous star fields appear far more structured and the many dark dust lanes weaving through them are clear to see. Still, don't expect to see the grainy mass of light, rich in colour and contrast typically seen in photos. ▸

M-GUCCI/ISTOCK/GETTY IMAGES, WILL GATER

A typically stunning image of the Orion Nebula, M42, as imaged through a 14-inch Cassegrain telescope, shows it awash with pinks and reds...



EYEPIECE SKETCH

...while a small scope will show the brighter structures but will not reveal colour

Bright emission nebulae

The bright colours of the Orion Nebula look very different through the eyepiece

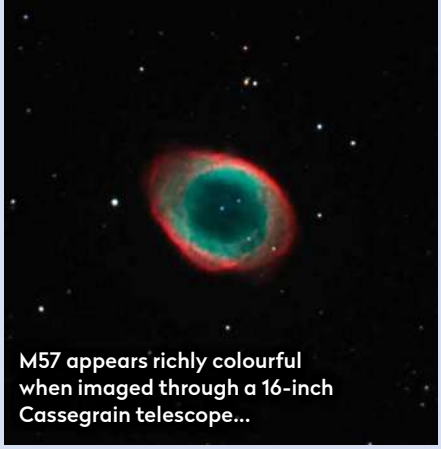
The image of the Orion Nebula, M42, shown here is fairly typical of how this spectacular object – a glowing cloud of gas with an embedded, nascent, star cluster – and others like it are revealed in long-exposure astrophotography. The vast swathes of hydrogen that make up the bright so-called 'emission' nebula shine with vibrant shades of pink and red, while the darker regions harbour subtle dust clouds with swirling filament-like forms.

Though these kinds of pictures of star-forming nebulae are ubiquitous in the world of imaging, they are nonetheless taken with cameras that are far more capable of detecting and collecting celestial light than our eyes, and so the visual impression of these objects in a small- to medium-aperture telescope is markedly different.

With some of the northern sky's most famous bright nebulae, from a site with relatively dark skies like the Orion Nebula and the Lagoon Nebula, you will be able to detect the soft glow of the nebulae around their embedded star clusters. In the case of M42 it's possible to see some of the brighter structures surrounding the Trapezium Cluster in a small telescope (see the eyepiece sketch, right), but there will be no dazzling colours.

Brightness and detail-wise, things improve if you use a larger aperture instrument and, perhaps, a light-pollution suppression or contrast-enhancing filter. In the largest instruments – think huge Dobsonian light buckets – M42 and the Lagoon Nebula can reveal breathtaking structure, and you'll start to see more details in some of the fainter emission nebulae too. But, again, the reds and pinks of astrophotos will not be there. At most, in our experience, you might detect a slight hint of a mint-green hue.

DZIKA_MROWKA/ISTOCK/GETTY IMAGES, JOHANNES SCHEDLER/CCDGUIDE.COM, ROBERT SCHULZ/CCDGUIDE.COM, WILL GATER X 3

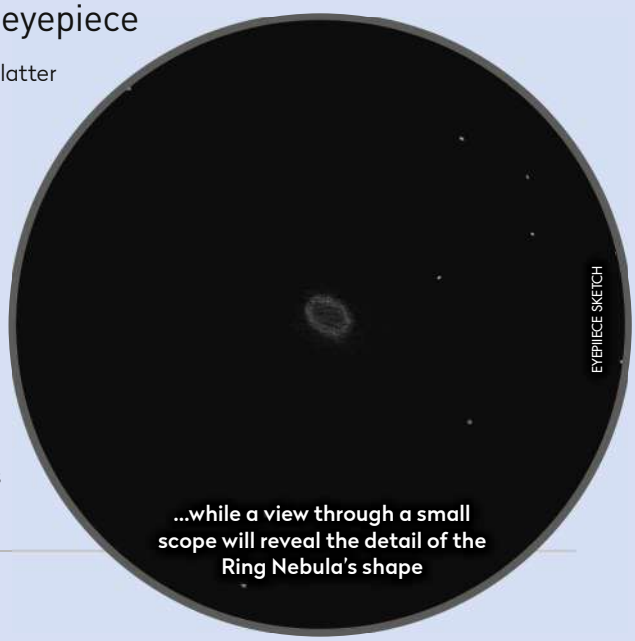


M57 appears richly colourful when imaged through a 16-inch Cassegrain telescope...

Planetary nebulae

Structure trumps colour when viewing through the eyepiece

The gaseous, glowing skeletons cast into space by Sun-like stars, known as 'planetary nebulae', can be hugely rewarding to track down if you're just starting to explore the deep-sky. In long-exposure images from professional observatories and advanced amateur astrophotographers these nebulae look like riotous splashes of colour against the black of space, but at the eyepiece they have an altogether more ghostly appearance. You can glimpse famous examples like The Dumbbell Nebula, M27, and The Ring Nebula, M57, through a pair of binoculars, with the former looking like a faint smudge of light and the latter like a diffuse, grey spot against the background stars. A small telescope will show the ring structure of M57 more clearly as well as the vague shape of M27, which is often likened to that of an apple core. With a large aperture telescope, M57 takes on a striking 'smoke ring' appearance that jumps out from the background, while M27 starts to show clear textures within its monochromatic form.



...while a view through a small scope will reveal the detail of the Ring Nebula's shape

Star clusters

Star clusters provide a dazzling display, but be wary of light pollution

The myriad star clusters scattered across the night sky can provide hours of enjoyment at the eyepiece. Dazzling open clusters, like the Pleiades, can take your breath away through a small scope at a dark-sky site. Even under suburban skies, the Pleiades appear as a mass of brilliant blueish-white points of light in a low power eyepiece – that's one providing a low level of magnification.

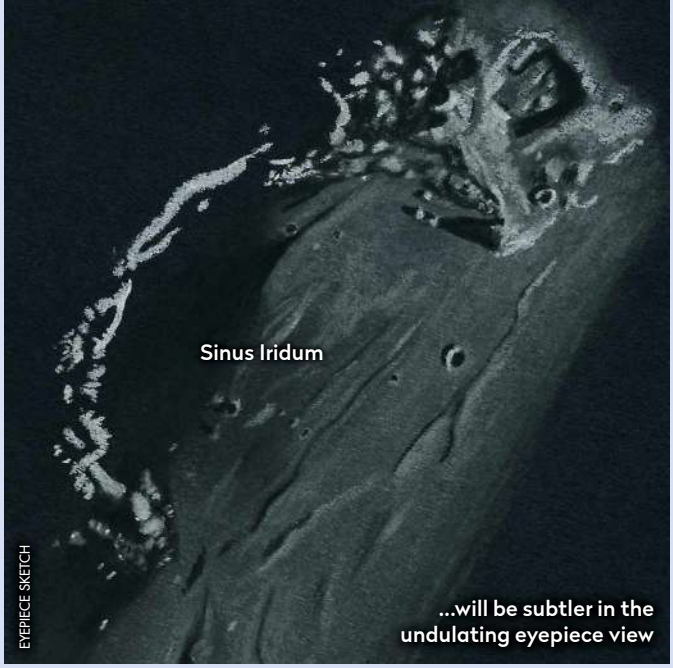
M13, as imaged through an 8-inch Cassegrain, reveals a wonderful splash of countless stars...

....while a view through a small scope's eyepiece reveals that as a concentration of brightness

One thing to remember when observing open clusters or selecting ones to view is that their individual members are affected by light pollution. If you have particularly bad skyglow where you are, any faint members will be hidden and this will reduce the cluster's overall impact.

In addition to open star clusters, the night skies also contain what are known as globular clusters. These are densely-packed spheroidal groups of stars which orbit around the disc of our galaxy. The fainter ones can sometimes be hard to spot with a small scope and many just look like a fuzzy patch of grey light. In medium- to large-aperture instruments, however, you begin to see that the patch is in fact a granular mass of countless stars. The bright ones can be utterly enthralling to take in through a big scope. Good 'starter' globulars that are well worth hunting down with a small scope at this time of year include the magnificent M13 cluster, as well as M92 and M5. ▸

The features around Sinus Iridum, the 'Bay or Rainbows'...



EYEPIECE SKETCH

...will be subtler in the undulating eyepiece view

SIMULATION

The lunar surface at the eyepiece

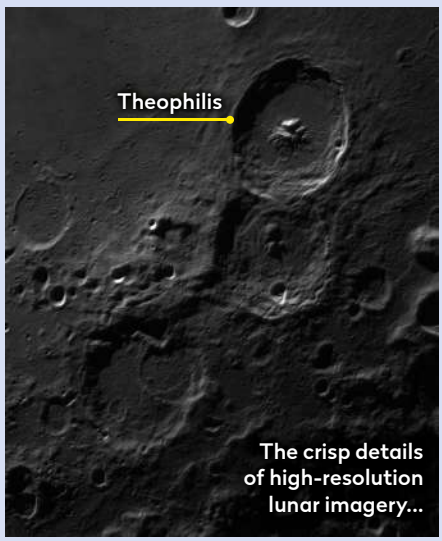
Though some details might be subtler, the Moon is still a spectacular sight

▲ This is how large the Moon's disc appears in the field of a 150mm scope, 15mm eyepiece and 2x Barlow lens

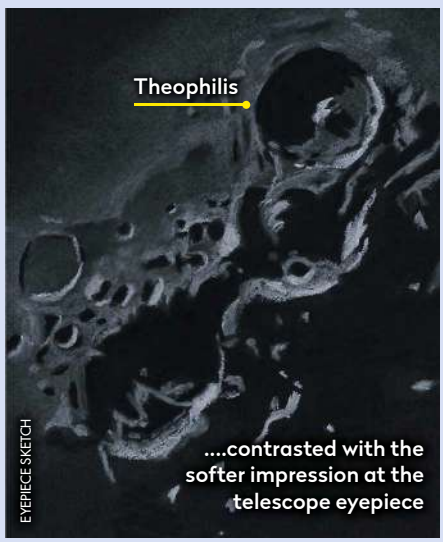
The Moon doesn't really suffer too much from a visual observing 'expectation gap' like faint deep-sky objects do – it's impressive even when seen through basic telescopes. But if astro images are your main reference points for what its surface features look like through a scope, do bear in mind that these usually show a level of fine detail that won't be visible to the eye.

Amateur imagery of the Moon is often captured using high frame-rate cameras. These are used specifically to overcome one of the things that pretty much defines the lunar visual observing experience: the undulating of the atmosphere. The cameras capture thousands of frames, which are analysed so that the sharpest data can be extracted. Our eyes don't have this luxury, of course, so at the eyepiece you'll see the Moon's surface gently wobbling as its light is distorted – only in very brief moments will finer details become visible. Not only that, but camera data is typically heavily processed on top of this. This means that at the eyepiece, the views of craters and mountains and the like are often softer and more subtle than sharpened photos might suggest they would be.

Through a small telescope at low magnification you'll usually be able to see the whole, or at least much of, the lunar disc in the eyepiece. As you up the magnification you'll be able to get a 'closer-in' view of features like craters, mountains and rilles; but be warned that doing this isn't like zooming in on a phone screen, where the image largely retains the brightness and clarity of the wide view. Increasing a telescope's magnification will make the overall view fainter, and if seeing conditions are poor you may not actually see that much more detail, as it'll be overwhelmed by the blurring of the turbulent atmosphere.



The crisp details of high-resolution lunar imagery...



EYEPIECE SKETCH

....contrasted with the softer impression at the telescope eyepiece

WILL GATER X 7, DIETER RETZL/CCDGUIDE.COM

The bright planets

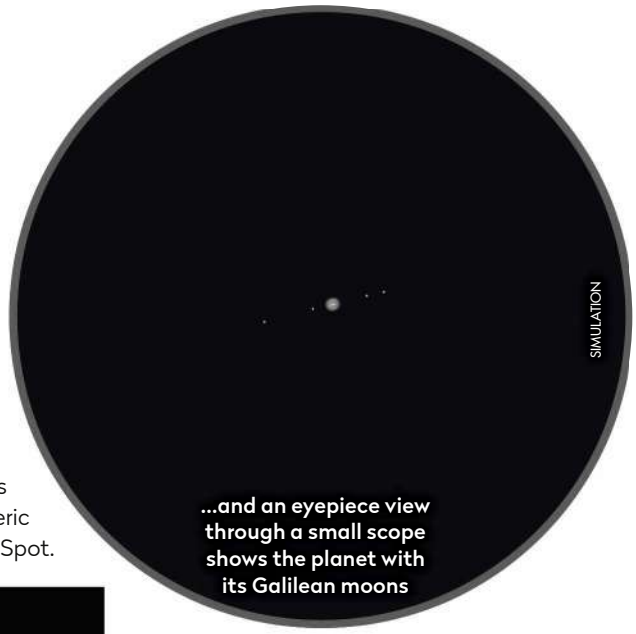
Distant worlds make captivating viewing

Your first sighting of a bright planet – Mars, Jupiter, Saturn, even Venus when it's in a dark, night-time sky – in a telescope eyepiece can be a very special thing. But, as with observing the Moon, prepare for a dynamic visual experience that will require patience and careful observation to make the most of the moments of good seeing. Though all four of the above mentioned worlds are captivating through a telescope of around, say, 150mm in aperture, their angular diameters – that is the size they appear to be through the telescope's optics – will be fairly small.

And, again, just like when observing the Moon, using a very high-power eyepiece won't necessarily give you a better view of the details on the planets – a medium level magnification is usually a better bet in most cases, rather than the shortest focal length eyepiece you have in your kit box.

Trained on Jupiter, a telescope with a 150mm aperture will show the main equatorial bands and indications of some of the subtler atmospheric details, as well as the Great Red Spot.

▲ **Jupiter, as imaged through a 14-inch Cassegrain telescope, reveals the fine detail of the gas giant's cloud systems...**



...and an eyepiece view through a small scope shows the planet with its Galilean moons

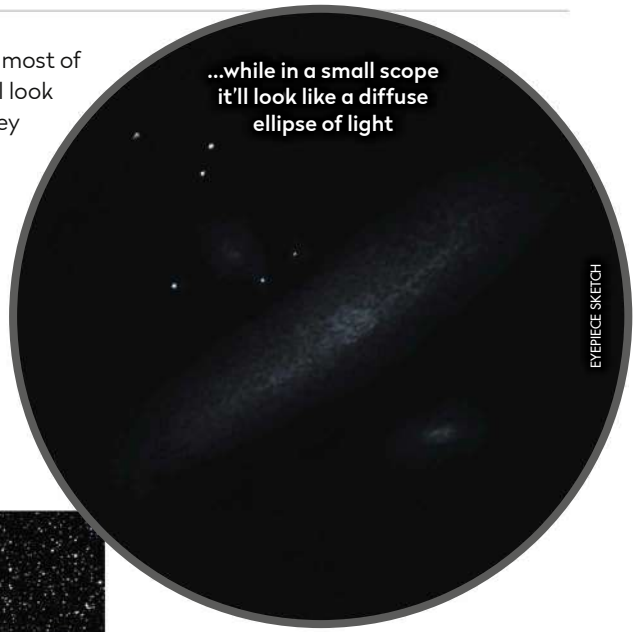
A similar setup will show the rings of Saturn and potentially hints of the soft banding on the planet – good seeing will also reveal the larger structures in the rings, namely the Cassini Division, the dark band located between the A and B rings.

Meanwhile, Mars at opposition will be a small ochre disc, but careful observation will show the more prominent, dark, so-called 'albedo' features, such as the famous Syrtis Major – which appears as a vaguely triangular dark-brown patch near the middle of the Red Planet's disc – and, possibly, one of the polar caps.

Galaxies

When it comes to visually observing galaxies, enjoy the thrill of the hunt

Perhaps the most challenging of all celestial objects for a beginner to observe with a small telescope are galaxies. Though you won't find any shortage of them listed in observing atlases and apps, do be prepared for the fact that most of these vast, stellar gatherings will look like faint smudges or spots of grey light in a small telescope – not the glittering swirls one might envisage based on the images taken by Hubble. That being said, there are some brighter galaxies that show interesting details at the eyepiece of a small scope. The iconic Andromeda Galaxy, M31, looks like a diffuse ellipse of light crossed by dark dust lanes, and you'll also be able to spot its two main satellite galaxies M110 and M32. In Ursa Major the pairing of M81 and M82, with their contrasting oval and narrow ellipse shapes, are fun to hunt down. And if your scope is on the larger side, the face-on spiral of M51, in Canes Venatici, can be an interesting object to locate from a site with dark skies.

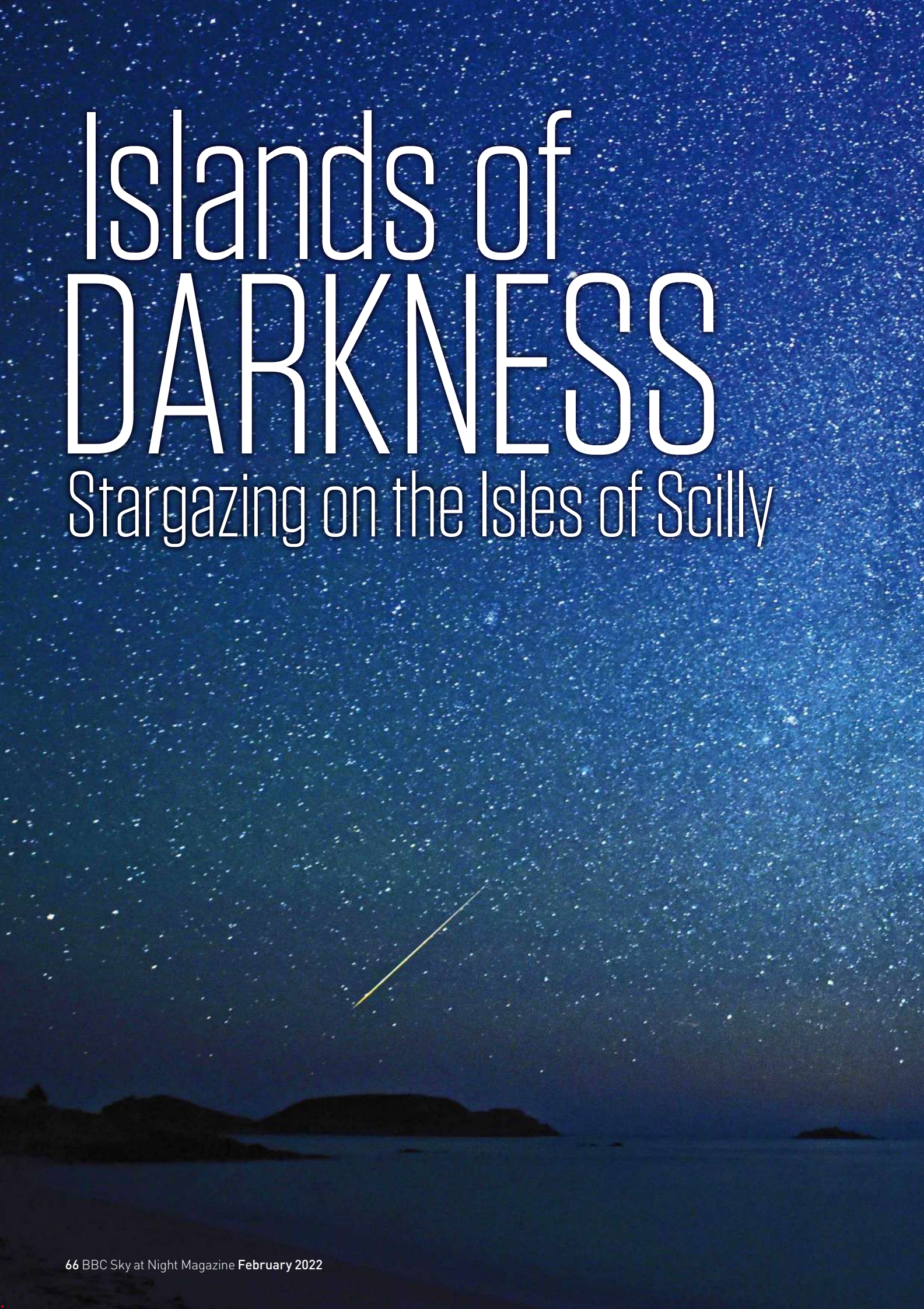


...while in a small scope it'll look like a diffuse ellipse of light

The Andromeda Galaxy, M31, looks spectacular in deep, long-exposure, astro images...

Islands of DARKNESS

Stargazing on the Isles of Scilly



A shooting star streaks over the tiny uninhabited island of Nornour

Though the skies were sometimes overcast, the sea air soon cleared the clouds

The Isles of Scilly are home to some of the darkest skies in the UK. **Ezzy Pearson** visited St Martin's island to experience them...

The Isles of Scilly aren't quite like anywhere I've ever been before. English country houses stand in the shade of palm trees, while dry stone walls line paths down to white sandy beaches. Take a swim off the shoreline and you'll find some of the clearest waters in the world. The feeling is a unique blend of tropical island and British countryside on these most southerly islands of the United Kingdom, where the Irish Sea meets the Atlantic.

But the real draw of the Isles of Scilly (at least for stargazers), is not what the island has, but what it does *not* have – light pollution. Located 45km off the Cornish coast, the skies above the Isles of Scilly are phenomenally dark. So when I stepped off the plane to a clear blue sky, I couldn't wait for night-time.

The airport is located on the island of St Mary's, but my destination was on St Martin's, meaning I had to hop on a boat over to the island. I was soon settling into my shepherd's hut next to the St Martin's Vineyard.

As it started to get dark, I made my way towards the reason for my trip – the island's community observatory. The idea of an observatory to take advantage of the fantastically dark ▸

COSMOS, EZZY PEARSON

The two community observatories built on the island of St Martin's

► skies here first arose in 2015, when Mark Holmes was on holiday with his family. Already an avid astronomer, Holmes was keen to do some stargazing. While he knew the skies would be dark, he wasn't quite prepared for when night fell.

"As soon as I got here I thought, "Goodness me, this is a phenomenal dark-sky site'," he remembers. "The first time I came here was with my wife, and then with my daughter. I just stood and watched them looking up at the sky; their breath was absolutely taken away by the depth of the sky, and the clarity. I realised that this is what is missing from astronomy, people have lost this connection to the night sky."

Building an observatory

A seed of an idea soon began to germinate. Holmes had already founded a community observatory in his hometown of High Legh in Cheshire, and he thought St Martin's could be the perfect site for another such facility. However, the notion truly blossomed after a chance chat with his B&B landlady Val Thomson.

"Out of curiosity, I asked him how he built that observatory, and what was involved," says Thomson.

▲ Mark Holmes first came up with the idea for an island observatory

◄ The 14-inch Meade LX200 ACF telescope inside one of the domes

EZZY PEARSON X 4, © GOOGLE, JOHN KEATES/ALAMY STOCK PHOTO, VISIT ISLES OF SCILLY, NIC HAMILTON PHOTOGRAPHIC/ALAMY STOCK PHOTO, ANTHONY COLLINS/ALAMY STOCK PHOTO, COSMOS

Getting to, and around, the Isles of Scilly

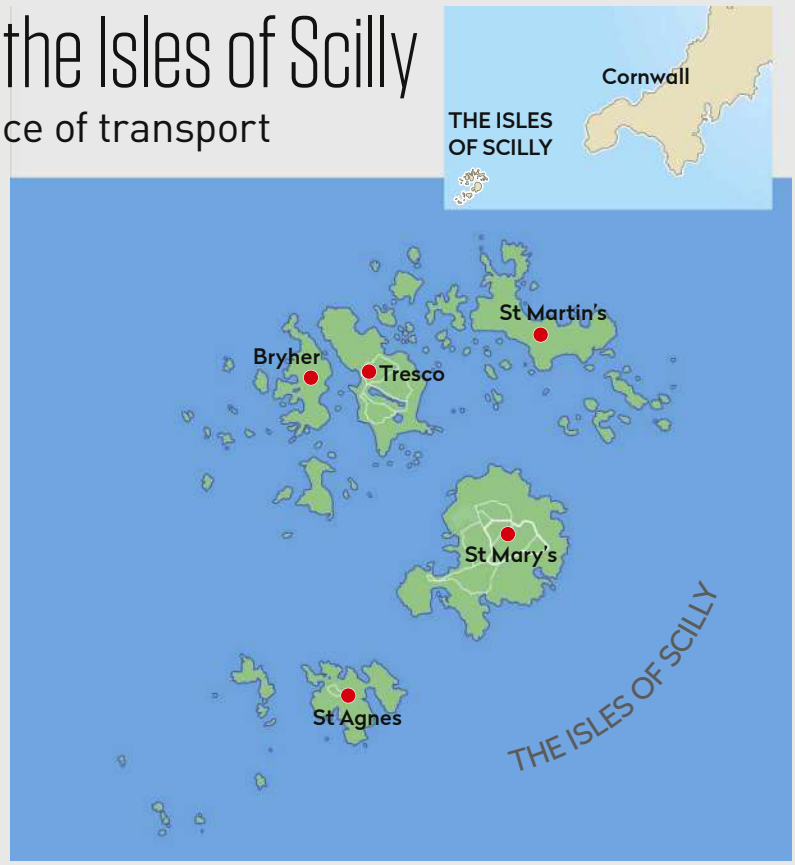
By sea or by air, you have a choice of transport

There are three main ways to get to the Isles of Scilly – by plane, ferry or helicopter. All operate seasonally (only the plane from Land's End operates year-round) and are weather dependant – poor conditions can cause flight delays and cancellations. The Scillonian Ferry operates in all but the worst weather – the crossing can be choppy at the best of times.

- Skybus flights:
  - From Land's End - £97.95 single
  - From Newquay - £138.95 single
  - From Exeter - £191 single
- Scillonian Ferry: from Penzance - £61.95 single
- Helicopter: from Penzance - £129 single

Prices correct at time of print. For more details visit: **www.islesofscilly-travel.co.uk** and **penzancehelicopters.co.uk**

'Tripper' boats shuttle to and from all five of the inhabited islands, just be sure to check the last return. Many of the boats are suspended in the winter months, so if visiting then – or if you want to travel out of hours – consult **www.scillyboating.co.uk/services** about private hire. Once on the islands, you'll be able to get everywhere on foot, though most accommodation providers will be happy to meet you on the dock when you arrive to carry luggage.



Places to stay on St Martin's

From camping to self-catered cottages to a luxury hotel, there are all sorts of options for accommodation on the island

Shepherd's hut at the Vineyard
A self-catered hut located next to the island's vineyard. It has a yard sheltered by hedges where personal telescopes can be set up.
www.stmartinsvineyard.co.uk

Karma hotel
A fabulous hotel with a prime beachfront location and an incredible view, for those who are after a comfortable stay with lots of little luxuries.
karmagroup.com

St Martin's campsite
If your prefer to be closer to nature, the campsite offers a low-cost option. Facilities include heated showers, laundry and free Wi-Fi.
www.stmartinscampsite.co.uk

B&Bs
For a homier feel, there are two guest houses on the island – Polreath (pictured) and Fuschia Cottage.
www.scillyman.co.uk
www.polreath.com

Self-catered cottages
If you're part of a larger group, there are a number of chalets and cottages run by the inhabitants of the island, which sleep up to six people.
www.stmartinsscilly.co.uk

Coastal setting: a full moon illuminates the night sky

"I thought, we are in a unique position here, so I called an informal meeting in the pub. There was lots of local interest, and from that we set up an astronomy society."

A plan in a pub quickly turned into a fully-fledged proposal to build an astronomical observatory, she says. "Originally we called ourselves the St Martin's Astronomical Society, but that got shortened to Smartarses! Then someone suggested COSMOS – Community Observatory St Martin's On Scilly."

The project took four years along with donations from private individuals, the Scilly Steamship Company and a grant of £60,000 from the Rural Development Programme for England. In 2019, the observatory became a reality.

Kitting it out

The observatory's two domes house a 14-inch Meade LX200ACF telescope and a 130mm Altair Wave refractor, alongside a hydrogen-alpha solar telescope. Next to these is a warm room with computers set up ready for image-processing and remote control of the telescopes. The observatory has been attracting astronomers and astrophotographers, keen to take advantage of the island's pristine skies. ▸

Incredible dark skies allow stargazers to enjoy the wonders of the Milky Way

"I came along with my camera bits and pieces, but you can't bring an awful lot on those flying boxes," says Mark Holmes, referring to the small, 17-seater planes that fly to the island. Although it is possible to bring more luggage when travelling via the ferry, taking a large telescope and mount island-hopping would be a formidable prospect. By providing high-end telescopes on the island, this hurdle is removed for astronomers, who only need to bring their far more portable cameras.

Finding dark skies

By now I was raring to get a look at these fabled dark skies. Just one problem – it had clouded over and started to rain. I wasn't about to give up though.

Throughout the day I'd seen that the sea air had kept the clouds constantly moving and even a completely overcast sky hadn't lasted for long. All I had to do was wait and, fortunately, I already had an evening of entertainment planned.

I'd come to the islands during Scilly Dark Skies Week, an event staged by COSMOS to help encourage beginner stargazers on the islands and the mainland by teaching them the basics of stargazing, while exposing them to the splendour of incredible dark skies.

The event opened with the COSMOS team explaining how the observatory came into existence, before socialising over a glass (or four) of wine. Soon enough, it was well into the evening, and so I thought I would duck my head outside to see if the clouds had cleared.

What greeted me were some of the darkest skies I'd ever seen. Even without dark adaptation and

The sea air proved to be my ally as it moved the clouds out of the way, revealing the brilliant bow of the Milky Way

with the hall light on behind me, it took less than 10 seconds for the band of the Milky Way to begin swimming into view. I dashed back inside to tell everyone that the sky had cleared. The COSMOS team ran to the dome, while the rest of us found a dark corner to observe from. One of the local astronomers began leading the beginner stargazers around the sky, pointing out Cassiopeia and how it led the way towards the Little Dipper and Polaris.

▼ The inky dark skies over the Isles of Scilly are ideal for keen astrophotographers

VISIT ISLES OF SCILLY, COSMOS, NEIL MCALLISTER/ALAMY STOCK PHOTO, ED MARSHALL/ALAMY STOCK PHOTO

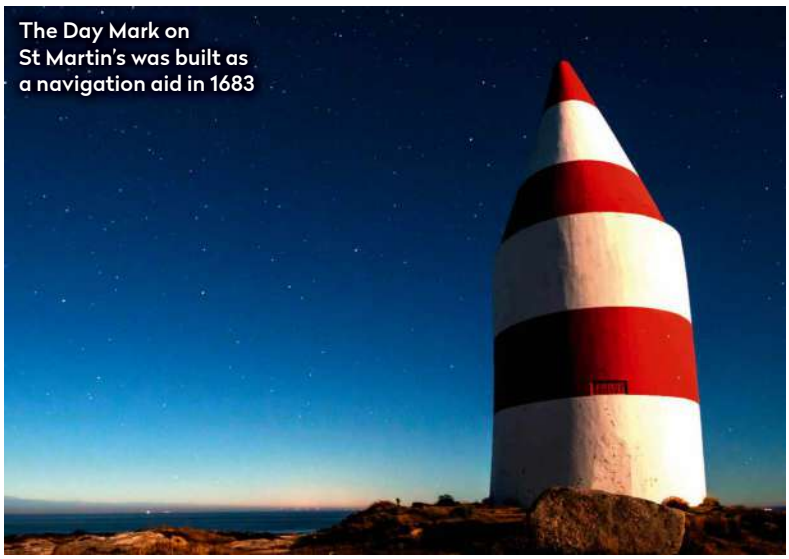
Things to do in the day

St Martin's is just as spectacular to see in daylight as in the dark

While stargazing might be the main reason you are visiting the Isles of Scilly, it's not the only thing you'll want to do – especially if you are travelling with family. Fortunately, there are lots of things to do during daylight hours and here's some recommendations:

- Take a tour and enjoy wine tasting at St Martin's Vineyard.
- Browse the local art and goods at the island's shops.
- Watch the local birds and wildlife, including seals which swim along the coast.
- Hire a kayak or paddleboard – rentals available April to October.
- Hop on the ferry and visit the other islands for the day.

Enjoy fine wines at St Martin's Vineyard



The Day Mark on St Martin's was built as a navigation aid in 1683

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University

It was halfway through this celestial tour that I realised something peculiar – the stars were not twinkling.

"That's because we're surrounded by the sea, it means the air is more stable," explained Thomson.

Without the turbulence caused by the thermal imbalance between the cool sea and the warm land that most of the UK experiences, the air on Scilly remains steady overhead.

This was evident when the COSMOS crew announced that the 170mm refractor was locked on Jupiter. When I looked through it I was greeted by an image of the gas giant as steady as I'd ever seen, with all four of its Galilean moons perfectly clear. We didn't have any idea how long it would be before the clouds rolled in and so we quickly filed past the eyepiece, sharing the view. For many there that evening it was the first time they had ever seen a planet through a telescope.

"I think that's what makes it all worthwhile – when someone looks through the telescope and sees Jupiter for the first time, and says 'wow, that's amazing'," smiles Anna Brown, who organised the Dark Skies Week. "It's about seeing everyone's enthusiasm, and helping them understand a bit more about the sky."

A starry guide home

Slowly though, the stars started to wink out. I had to assume it was the clouds rolling in – with no Moon or light pollution to illuminate them, it was only possible to tell where the clouds were by the absence of stars. It was a strange experience, watching blackness roll over the sky and cover the bright points of light.

It was time to make my way back to my shepherd's hut. Carefully though – as soon as I was away from the light of the hall, I couldn't even make out my hand in front of my face, let alone see my feet, one of the drawbacks of such incredibly dark skies. There was no choice but to forego my dark adaptation and switch on the torch.

I kept an eye on the sky, and once again the sea air proved to be my ally as it moved the clouds out of the way, revealing the brilliant bow of our home Galaxy and the thousands of stars normally hidden from view behind the orange glow of the 'city' I like to call home. Spellbound, I turned off the torch, let my eyes readjust and allowed the Milky Way to lead me to my bed.

The fundamentals of astronomy for beginners

EXPLAINER

Exoplanets – 30 years of discovery

Penny Wozniakiewicz looks at advances in the eld since the rst worlds were announced

On 9 January 1992, astronomers Aleksander Wolszczan and Dale Frail introduced the world to the first two planets to be found outside the Solar System, alien worlds observed orbiting the pulsar PSR B1257+12, around 2,300 lightyears away. The hunt for 'exoplanets' – as they are also known – was then, as now, heavily driven by our quest to find out just how unique (or not) our Solar System is, and whether there is life beyond it.

Given the latter aim, finding exoplanets orbiting a pulsar – effectively a dead (no longer burning) star – is far from ideal. Rather fittingly, a competition run by the International Astronomical Union (IAU) resulted in the pulsar and its planets being named after various macabre characters from mythology and popular culture: Lich for the star, and Draugr, Poltergeist and Phobetor for its worlds (the third was discovered two years later). Nevertheless, the discovery spurred interest in strange alien worlds among the public and the scientific community, and now, after three decades of searching, some 4,500 confirmed exoplanets have been identified.

▲ **As our observing technology advances, so does the potential for finding Earth's twin among the huge variety of exoplanets**

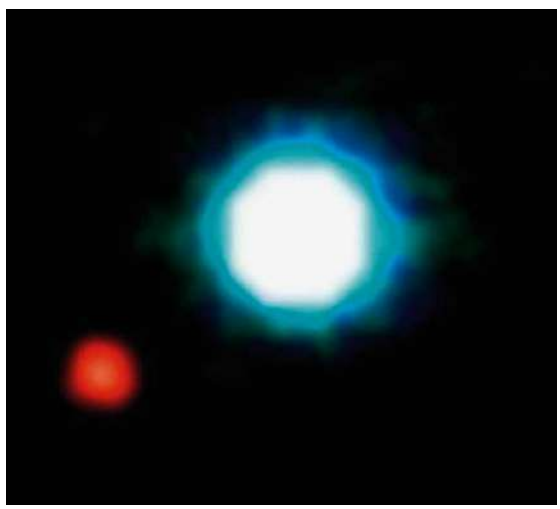
So many planets to choose from

And strange worlds they are indeed – the sheer variety observed among these exoplanets is vast. To date, they range from rocky terrestrial planets similar in size to Earth, to gas giants much larger than Jupiter; from extremely hot to exceedingly cold, with orbits taking them insanely close or excessively far from their stars. They have also been found around all sorts of stars – small, large, young, old and dead. Some even orbit multiple star systems, while so-called 'rogue planets' do not even orbit a star.

Both ground and space-based telescopes have been instrumental in exoplanet discoveries, perhaps most notably the Kepler Space Telescope, which is credited with more than 2,600 confirmed finds. Although it is possible to directly image some exoplanets (particularly those that are bright, massive and orbit at large distances from their star), the vast majority of exoplanets have been identified through indirect methods – the planets are found by studying the effect they have on their stars.

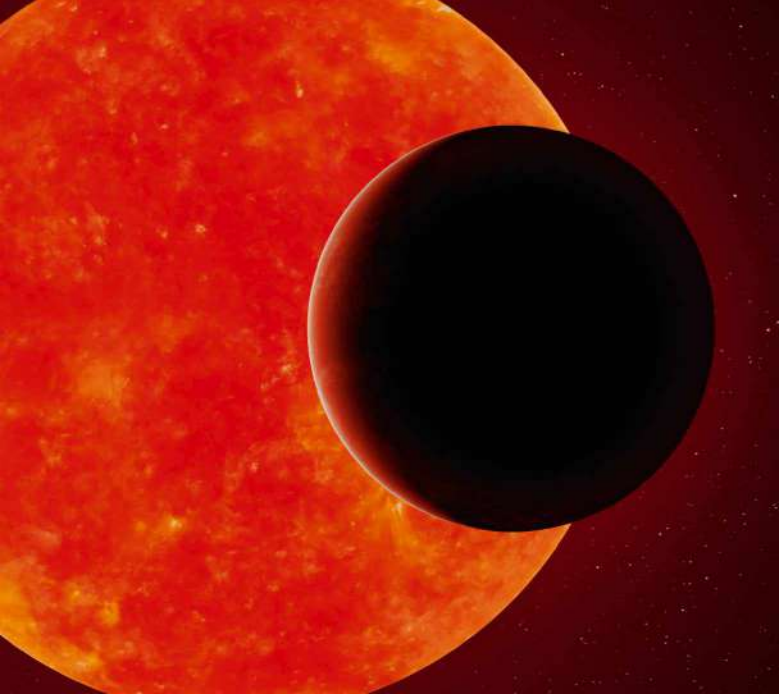
For example, the 'radial velocity' and 'astrometric methods' both search for evidence of wobbles in the motions of stars caused by orbiting planets, while the 'transit method' studies the dip in the brightness of stars caused as planets pass in front of them.

Combined, these studies allow us to work out details of each planet's orbit and size, and then



► **Making history: in 2004 the exoplanet 2M1207b (in red) became the first to be directly imaged near its host star, the brown dwarf 2M1207 (centre)**

OORKA/ISTOCK/GETTY IMAGES, ESO, NASA/GSFC/CIL/ADRIANA MANRIQUE GUTIERREZ, DZIKA_MROWKA/ISTOCK/GETTY IMAGES, NASA/ESA AND G. BACON (STSCI),



determine whether it is a rocky terrestrial planet or a gas or ice giant, and whether it orbits within the star's habitable zone. This is the region around a star where temperatures may permit the existence of liquid water on a planet's surface – and from what we know about life, liquid water is an essential ingredient.

But finding a planet like Earth in the habitable zone of its star does not mean liquid water is present or that it will be habitable – key to the ability to host liquid water is the presence of an atmosphere to maintain sufficient surface pressure. Atmospheres also provide a means to explore the conditions present on these planets, as their compositions may reveal details of surface processes and even potentially the presence of life.

On the trail of exoplanets

Studies of exoplanet atmospheres are performed using spectroscopy. For a transiting exoplanet this involves measuring the intensity of the star's light at different wavelengths as the planet passes in front. Gaps in the spectrum result from absorption by elements or molecules present in its atmosphere.

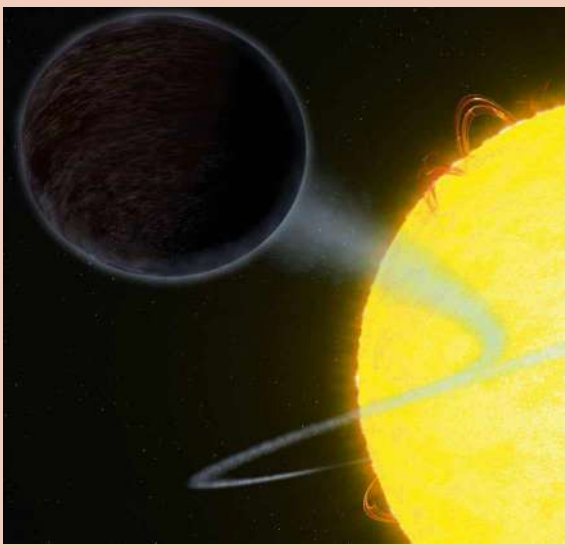
▲ Above left: a common way to detect exoplanets is by using the 'transit method'; where a dip in the brightness of a star can indicate a passing planet

Above right: as it unravels the mysteries of early planetary systems, the James Webb Space Telescope (JWST) will be on the look out for new worlds

Several different atmospheric constituents have been identified in exoplanet atmospheres, including water vapour, carbon dioxide and methane, and scientists have even interpreted details such as the presence of clouds, rain and extremely high-speed winds on some.

Current studies estimate that trillions of planets could exist in our Galaxy, so it's safe to say that we have barely touched the surface when it comes to finding and learning about exoplanets. As new telescopes come online from now and in forthcoming years, such as the long-awaited James Webb Space Telescope (JWST), the Nancy Grace Roman Space Telescope (2027) and the Atmospheric Remote-sensing Infrared Exoplanet Large-survey (2028), they will surely identify more exoplanets and investigate their atmospheres – perhaps one day finding that exoplanet which is truly similar to Earth.

Dr Penny Wozniakiewicz is a planetary scientist and space dust expert based at the University of Kent



▲ WASP-12b, a jet black planet being pulled apart by its host star, absorbs 94 per cent of the light on its surface

Exoplanets, great and small

The search for exoplanets has revealed a previously unimaginable variety. We reveal some notable examples:

WASP-12b is one of the largest gas giants observed, twice Jupiter's size. Discovered in 2008, it orbits so close to its star that it's being torn apart!

Mysterium Cosmographicum TOI-849b is an extremely dense rocky planet lacking atmosphere, which was discovered in 2015. It is thought to be the core of a gas giant.

Proxima Centauri b is our nearest neighbour at 4.22 lightyears away. Spotted in 2016, it's a bit bigger than Earth and orbits a small dwarf star.

Kepler 452b is a contender for the title of 'most Earth-like planet', Kepler 452b (discovered in 2015) orbits a similar star to our Sun at approximately the same distance in about the same amount of time.

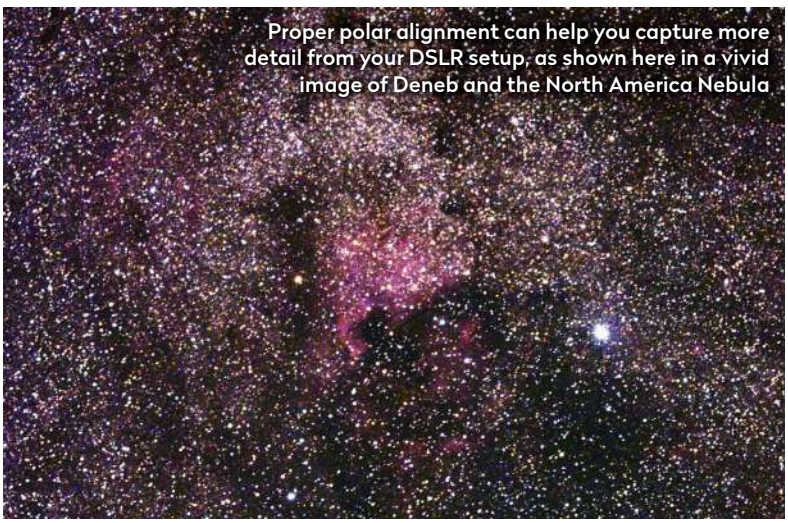
The Kepler-90 system is the largest system of planets outside our own Solar System, thanks to the discovery of an eighth planet around this star in 2017.

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Polar align your star tracker DSLR mount

Increase your camera's exposure times, while keeping stars sharp, with accurate polar alignment



Proper polar alignment can help you capture more detail from your DSLR setup, as shown here in a vivid image of Deneb and the North America Nebula

Take any photo of the night sky with a DSLR camera and after a certain length of exposure, the stars will start to trail due to the apparent movement of the stars (in reality, Earth's rotation).

Not so long ago, you needed a large equatorial mount and some familiarity with the 'dark art' of image processing to track the movement of the stars. Today, though, there are many small, lightweight, star-tracking mounts that allow us to attach a DSLR camera with a lens or even a small telescope, and to follow the stars' apparent movement to get extended exposures.

These portable mounts still have one important thing in common with their heavier counterparts: they require polar alignment to track the night sky successfully. Most star tracker mounts use a small polarscope to align on Earth's axis of rotation, which, if you extend this line out into space, is slightly offset from the easy-to-locate Polaris (Alpha (α) Ursae Minoris) – the 'North Star' or 'Pole Star'. Aligning usually means placing the star roughly in the polarscope's field of view and rotating the right ascension (RA) axis to the correct point, to position Polaris into a small circle on the graticule – the 'clock face' pattern that is seen through the eyepiece of the polarscope.

ALL PICTURES: PAUL MONEY

Paul Money is an astronomy writer and broadcaster, and the reviews editor of *BBC Sky at Night Magazine*

In some cases, you can align an engraved set of constellations on the graticule (such as Cassiopeia and Ursa Major) with their positions in the sky. Your level of success, however, is determined by how accurately you can perform the alignment for your equipment and requirements. A large system with a telescope needs to be more accurately aligned to track the stars successfully.

Longer exposures, deeper targets

Let's look at how a DSLR star tracker can help increase exposure times with polar alignment. If you are using a star tracker and a camera with wide-field lenses (up to 35mm) then an approximate alignment with Polaris in the centre will typically produce exposures of a couple of minutes. In contrast, if you perform a proper polar alignment, you can push the exposures up to 10 or even 20 minutes with the same lenses, depending on the level of light pollution.

So, the ability to polar align is vital for getting the most out of your DSLR star tracker. In addition, the more accurately you can perform the polar alignment, the longer lenses and exposures you can employ, despite the increased weight on the system.

Our preferred method is to use either the Sky-Watcher SyncScan Pro app (for Android and iOS, **bit.ly/3yuVHCQ**) or the iOptron Polar Scope app (for iOS only, **apple.co/33gFBku**) to show where to place Polaris on the graticule, based on the hands of a clock. By ensuring that the '0' is lined up with the vertical axis of your mount while looking through your polarscope, you can then use either one of the apps to help you position Polaris correctly; just follow the step-by-step guide opposite.

Once you've followed the steps you can look forward to capturing great data and producing stunning images. And, as a bonus, you can also use the same method to align your heavier equatorial mount.

What you'll need

- A star tracker, a polarscope illuminator, a tripod, an EQ wedge or a tripod with a normal pan head, and a DSLR camera with assorted lenses.

Step by step

Step 1

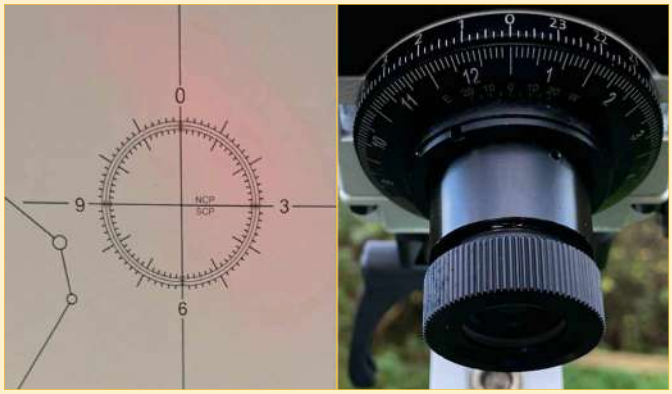
Assemble your particular star tracker (for this demonstration we are using the Sky-Watcher Star Adventurer 2i).

Attach it to a tripod and roughly aim it towards the north. Ideally, use an equatorial wedge as this helps with latitude adjustment, but if you don't have one you can try angling the tripod's panhead instead.

Step 2

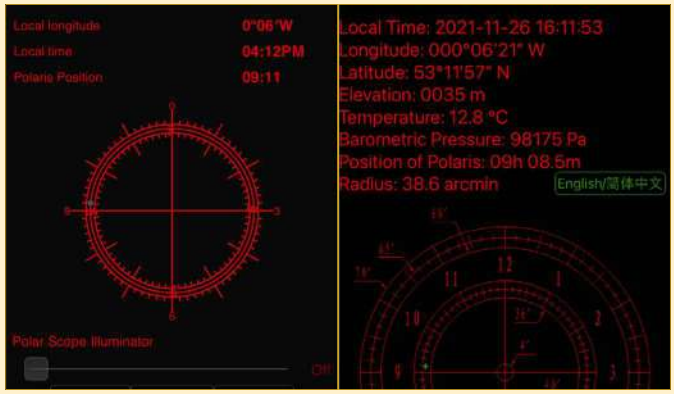
Next, ensure that your setup is level by using the spirit level that you'll find integrated into the wedge, and uncap the mount covers to reveal the integrated polarscope.

You can now use the altitude and azimuth adjustment knobs to roughly place Polaris near the centre of the polarscope's field of view.



Step 3

Attach the polarscope illuminator or use a red torch to illuminate the graticule (left). Unlock and align the RA axis by sighting through the polarscope and rotating it until the graticule has '0' at the top and is in line with the mount body.



Step 4

The polarscope graticule resembles a clock face, so now using either the SynScan Pro app or the iOptron Polar Scope app, find where Polaris should lie along the circle of the graticule for the particular time and date that you're out under the stars.

Step 5

Using the altitude and azimuth adjustment knobs, sight through the polarscope and position Polaris on the graticule as indicated in the app (Step 4). Remove the polar illuminator and add the camera with a wide-field lens, and start taking exposures.

Step 6

To get closer to your objects you can fit a longer, heavier lens. Use the monunt's (optional) dovetail L-bracket and counterweight shaft with the counterweight attached here.

The bracket has a slot that will allow you to polar align as above with the extra photography equipment attached.

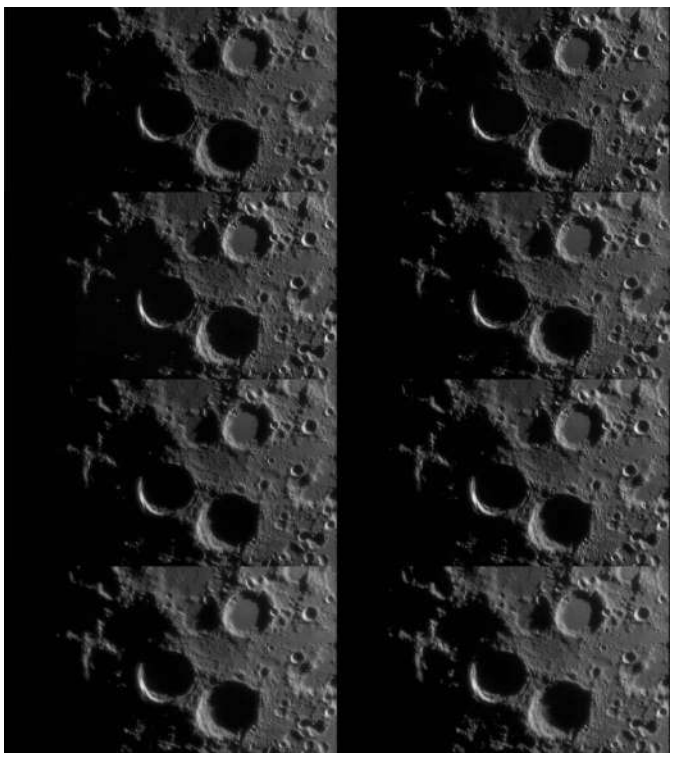
Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Imaging the Moon's play of shadows

Intriguing features play hide-and-seek as the terminator crosses the lunar landscape

Whether you're looking at the Moon through an eyepiece or via a camera sensor, the features you see will initially appear fairly static. But, if you pick a feature close to the terminator and monitor its appearance over 30-minute intervals, you will see changes. This stands to reason, because the view you get from one night to the next is different and changes must have occurred over the hours between views. Each night the lunar terminator moves about 12° in longitude around the Moon's globe. In this article we'll look at how to capture a sequence of images to show the play of shadows around a lunar feature.



▲ **Pick a feature near the lunar terminator, such as the 'Lunar X', for a sequence of shadow shots**

Look for high peaks

For the best results you'll need to start observing a lunar feature when the Moon is visible for (at least) a few hours above the horizon. The Moon's altitude needs to be 30° or higher for the most stable results. Try and pick surface subjects that have a good relief height as these will generate the most dramatic and fast-moving shadows. Look for flatter surrounding areas as these are better than complex, contoured ones for showing faster moving shadows.

Mountain ranges make excellent subjects for this as many border the relatively flat lava surfaces of adjacent lunar mares. High peaks will cast dramatic pointed shadows across a mare's surface and these appear to move surprisingly fast, certainly quickly enough to show the sort of motion we are after here.

Choose a night which looks as if it will give you a few hours of clear sky. There's nothing more annoying than having to terminate a sequence due to cloud or high haze. The latter will also affect the appearance of your results and, if creating an animation, will cause unwanted frame flickering which will detract from the overall effect.

Shadow movement animations need magnification for the best results. Low image scale shots can show shadows change over time, but it takes longer for the movement to be revealed. But a high-resolution, highly magnified image can show impressive shadow movement over a short time. High frame rate captures work best for this, as they give the sharpest results. Use a high frame rate camera and capture around 1,000 frames for each shot. Process the results with your preferred registration-stacking software (eg AutoStakkert!) combining the final results into your animation.

Be sure to maintain a constant interval between sequences, or the shadow movement will appear to judder. Start with 30-minute intervals to give a decent number of frames to animate. If you like the end result, consider doing animations using shorter time intervals to give more frames.

Equipment: a telescope fitted with a high frame rate camera, plus a polar aligned, driven tracking mount

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

STEP 1

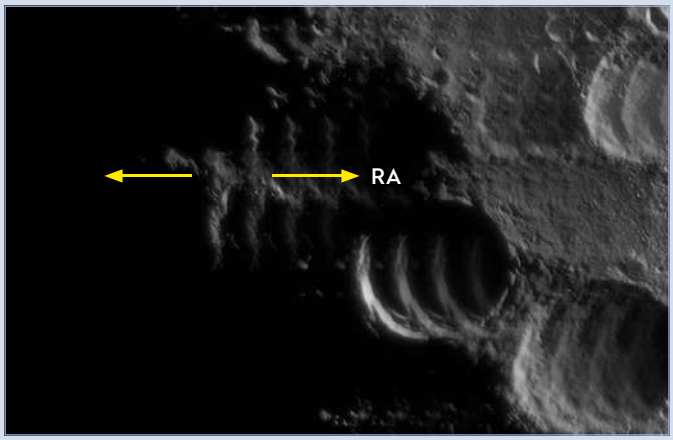
The best results will come from usin a telescope with a hi h frame rate ima in camera. If usin an infrared sensitive mono camera, consider fittin an infrared pass filter (pictured), which will help stabilise the view, deliverin sharper results. Use a polar-ali ned, driven equatorial trackin mount.

STEP 2

While low ima e scale is easier to capture, it's less adept at showin shadow movement over short time intervals. Hi h ima e scale requires more ima in skill and hi her telescope precision, but even short capture periods should show ood movement. A focal len th of 4,000mm or more is recommended.

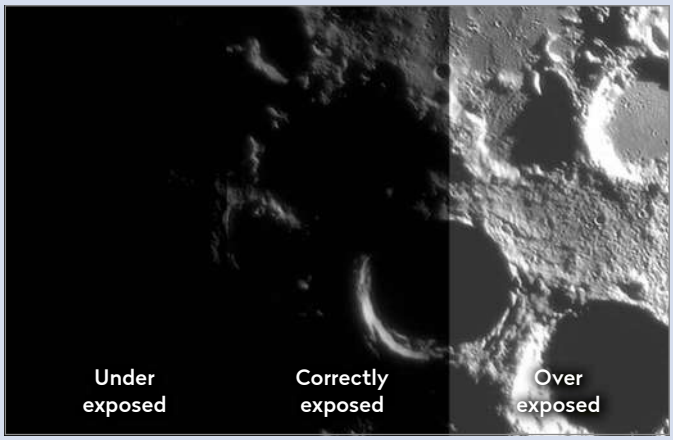
STEP 3

Ideally, select a night when the Moon will be higher than 30° altitude for a few hours and the weather forecast shows good clarity for that period. Your capture attempts should be taken under dark-sky conditions to avoid contrast variation. A gap of 30 minutes between shots is best to start with.



STEP 4

Choose a relief target near the terminator, preferably showing a lot of height variation, such as a mountain. If the Moon is waxing the target slowly reveals over time. If waning, the target slowly disappears. Rotate the camera so slewing in RA (Right Ascension) moves the target parallel to the bottom edge of the imaging frame.



STEP 5

Re-centre the target and focus accurately. Next, make a note of features near the corners of the frame. These can be used to re-frame should the telescope drift position between captures. Adjust camera settings to optimise exposure while maintaining a decent frame rate. Capture 1,000 frames and process the result.

STEP 6

Repeat and process after each capture. When the run is complete, load all the frames in order into a layer-based editor, one result per layer. Align all layers and create an animated sequence if your software allows animation. Or save the frames individually and use a program like PIPP to create a sequence.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Create a stacked image of our Galaxy

Use image-stacking software to enhance detail in different areas of a Milky Way image

ALL PICTURES: MARY MCINTYRE

An essential tool for astrophotography, image stacking – or using software to effectively lay multiple exposures on top of one another – allows you to build up a much longer total exposure time and to reveal more detail in your image, something that is particularly helpful if you don't have a tracking mount and need to take short exposures. Stacking also increases the 'signal to noise ratio' – the ratio between the light you want to capture (the signal) and unwanted artefacts (noise) – which produces a smoother image.

To do the stacking, we'll be using a piece of free Windows software called Sequator (**https://sites.google.com/view/sequator**) that can stack your night-sky images quickly and includes clearly explained instructions. It can be used to stack any images that contain stars, but is ideal for wide-field images as well as for creating star trails. Here we're going to look at how to use Sequator to stack images of the Milky Way.

Before we get started, however, there's one key feature of Sequator that should be flagged up: it allows you to select a specific area to stack from an image, as well as any areas you want to leave untouched. For example, if you are stacking images with an area of interest in the foreground, you may find that the stars are moving relative to the foreground from one exposure to the other. But you want to avoid the foreground becoming blurry when Sequator stacks the images, which will happen when it rotates each frame slightly to fix the stars in the image.

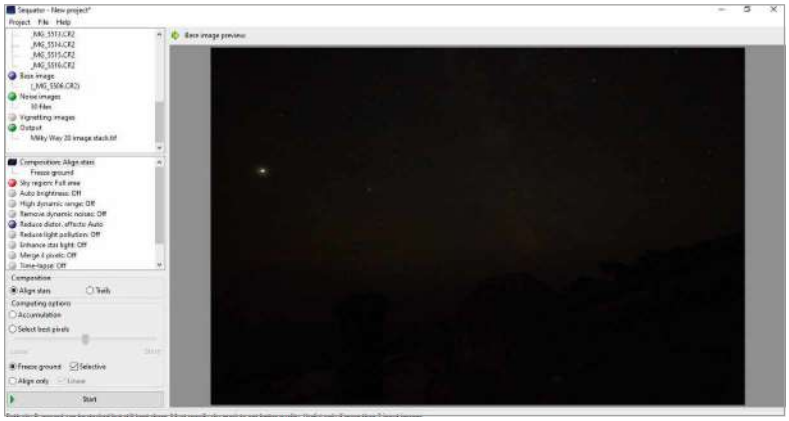
To deal with this, normally you would need to blend one of the individual exposures in Photoshop or similar, but doing this seamlessly can be difficult. Sequator will do this for you, and the result is a stacked image that doesn't have a blurry foreground.

▲ Before: an unprocessed initial exposure of the Milky Way, taken from Dorset, is murky and lacks detail

After: Sequator carries out separate adjustments to the foreground and sky regions during its stacking process to produce a wonderfully transformed final image

Enhancing different sections

Let's see how Sequator does this on our Milky Way images. We started with 20 exposures of our Galaxy taken on a Canon EOS 1100D DSLR camera and a 10-18mm lens on a tripod, each 25 seconds at ISO 3200 with an aperture of f/4.5 (see above, left). We shot in RAW format and included 30 dark frames taken with the same settings and the lens cap on.



▲ **Screenshot 1: In Sequator, the 'Freeze ground' option will ensure that the foreground doesn't become blurry when you are working on the sky region**

▲ **Screenshot 2: To select the areas to stack and the areas that will remain static, click on the 'Sky region' tab and select the 'Irregular mask' button**

To begin the stacking process, open Sequator and drag and drop your images into the Sequator window. Once this is done, the 'File Category' box will pop up. Next, select 'Star images'. If you have taken dark frames, drag and drop these too and from the 'File Category' box select 'Noise images'. You can also include flat frames, but we didn't use them here.

Sequator requires you to name your output file before you stack. To do this, double-click the 'Output' button at the bottom of the top left window. It will default to the folder that your original images came from, so just type your chosen filename into the 'File Save' window. Next, we need to set the stacking parameters. To get the software to stack on the stars, you need to click on the word 'Composition' and in the box below select the 'Align stars' option. Below that, you also need to select the 'Freeze ground' tab (See Screenshot 1). In order for this 'Freeze ground' feature to effectively freeze the foreground of the image, it's important that the camera doesn't move between taking each of the exposures.

Now we need to select the area that we want to stack and the area we want to remain static (see Screenshot 2). To do this, click on the 'Sky region' tab and in the bottom window click on the 'Irregular mask' button. When you move your mouse over the image you will see a circular brush appear. Left click and hold down the mouse button to paint out the sky region that you wish to stack. By using the mouse tracking-wheel to adjust the brush size, it will make it easier to get around the foreground shape. If you happen to make an error while painting with the brush, you can undo it with a right click of the mouse.

If your image has a lot of light pollution, you can double-click on the 'Reduce light pollution' tab. We didn't need to use this feature in our example, however, because our images were taken from a dark-sky location. The next stage is to increase the brightness of the stars. Do this by double-clicking on the 'Enhance star light tab' and use the slider in the bottom window to select the strength of this enhancement. In our example we kept the slider in the middle. Next, click the 'Start' button to begin the stacking process (see the stacked TIFF image, left).

Once done, you can complete the processing in your favourite image-processing software. Our final image of the Milky Way (opposite, top, right) has enhanced the detail of the foreground and brought out the wonderful starry features of our Galaxy.

▲ **Once the RAW files,have,been, through Sequator, the stacked TIFF file,of,the,Milky, Way is ready for final,adjustments, with image-processing software**

3 QUICK TIPS

1. In Sequator, light frames are known as 'Star images', dark frames are 'Noise images' and flat frames are 'Vignetting images'.

2. To prevent a blurry foreground, don't forget to select the 'Freeze ground' tab when you select your composition.

3. Double-click the 'Output' tab and enter the filename of your stacked image before you hit the 'Start' button.

Mary McIntyre is an outreach astronomer and teacher of astrophotography

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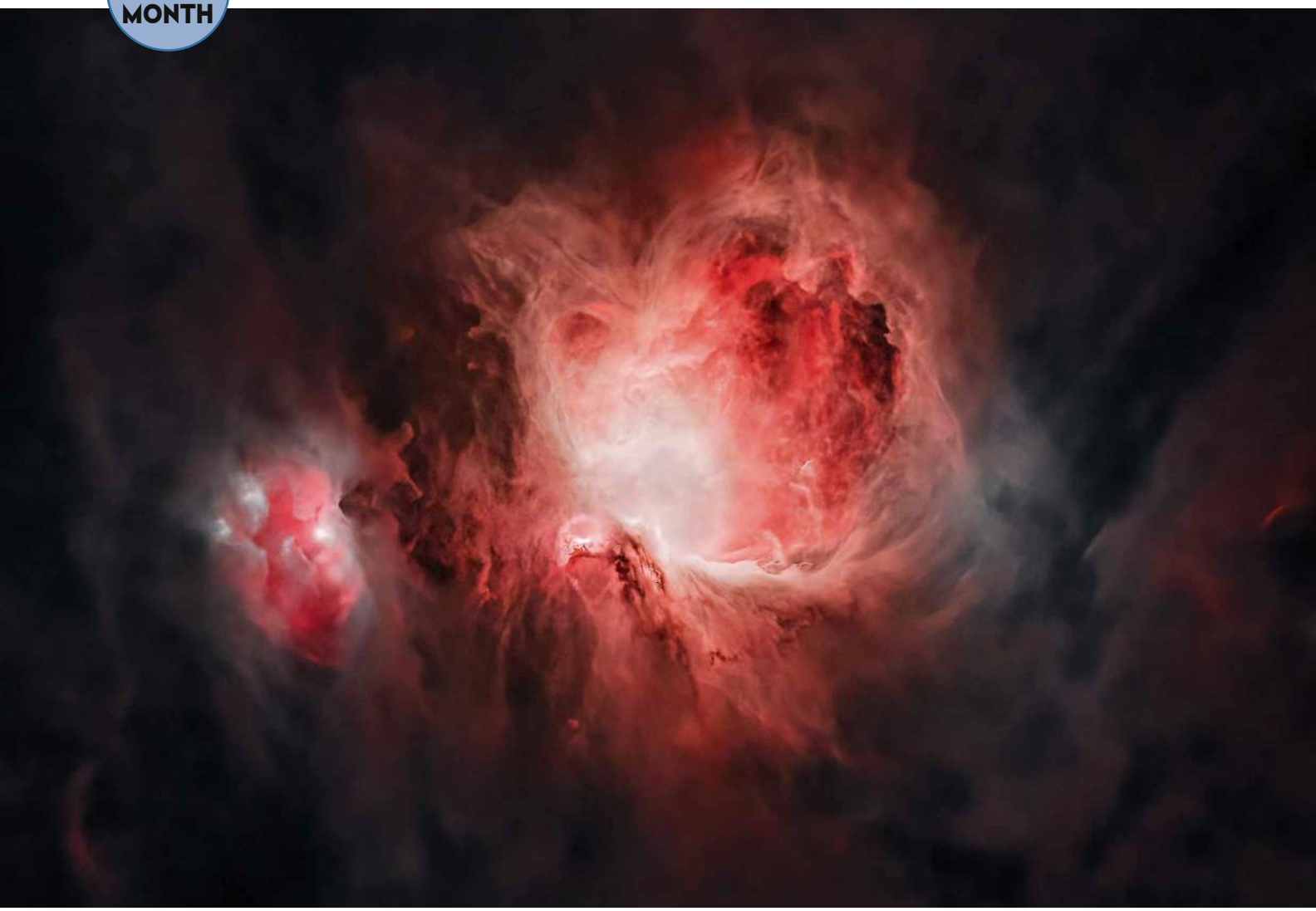


△ The Orion Nebula

Danny Lee, Folkestone, Kent, 7 November 2021

Danny says: "This was my first attempt at imaging the Orion Nebula. At this time of year, it skims the neighbouring rooftops from my back garden, so I was happy I was able to capture it. I tried to show some of the dust around the nebula and I removed the stars in post-processing to help achieve that."

Equipment: ZWO ASI2600MC Pro camera, William Optics RedCat 51 APO refractor, Sky-Watcher EQ5 Pro mount
Exposure: 36x 300", 3h total
Software: DeepSkyStacker, PixInsight, Lightroom

Danny's top tips: "The Orion Nebula's core is bright, so add in some shorter exposures to retain detail in the brightest areas. I try not to be too aggressive in photo-editing software when I set the 'black point' – the darkest area of the image on the left of a histogram. I set the arrow about 10–20 per cent in from the left to get a more natural look and to avoid losing detail in the darkest regions. Taking regular breaks helps too: fresh eyes help to identify things to improve on."

◁ Northern Lights

Tomáš Slovinský, Tromsø, Norway, 27 October 2021

Tomáš says: "During a journey with friends to Tromsø we enjoyed a great time on the beach watching the Northern Lights. Suddenly, a sky full of aurora exploded."

Equipment: Canon 6D DSLR, Sigma 28mm Art lens, tripod **Exposure:** ISO 4000 f/1.8, 2.5" **Software:** Lightroom

▽ The Pleiades

Basudeb Chakrabarti and Goutam Dey, Darjeeling, India, 6 November 2021

Basudeb says: "On a clear night, we imaged the Pleiades, rising and setting."

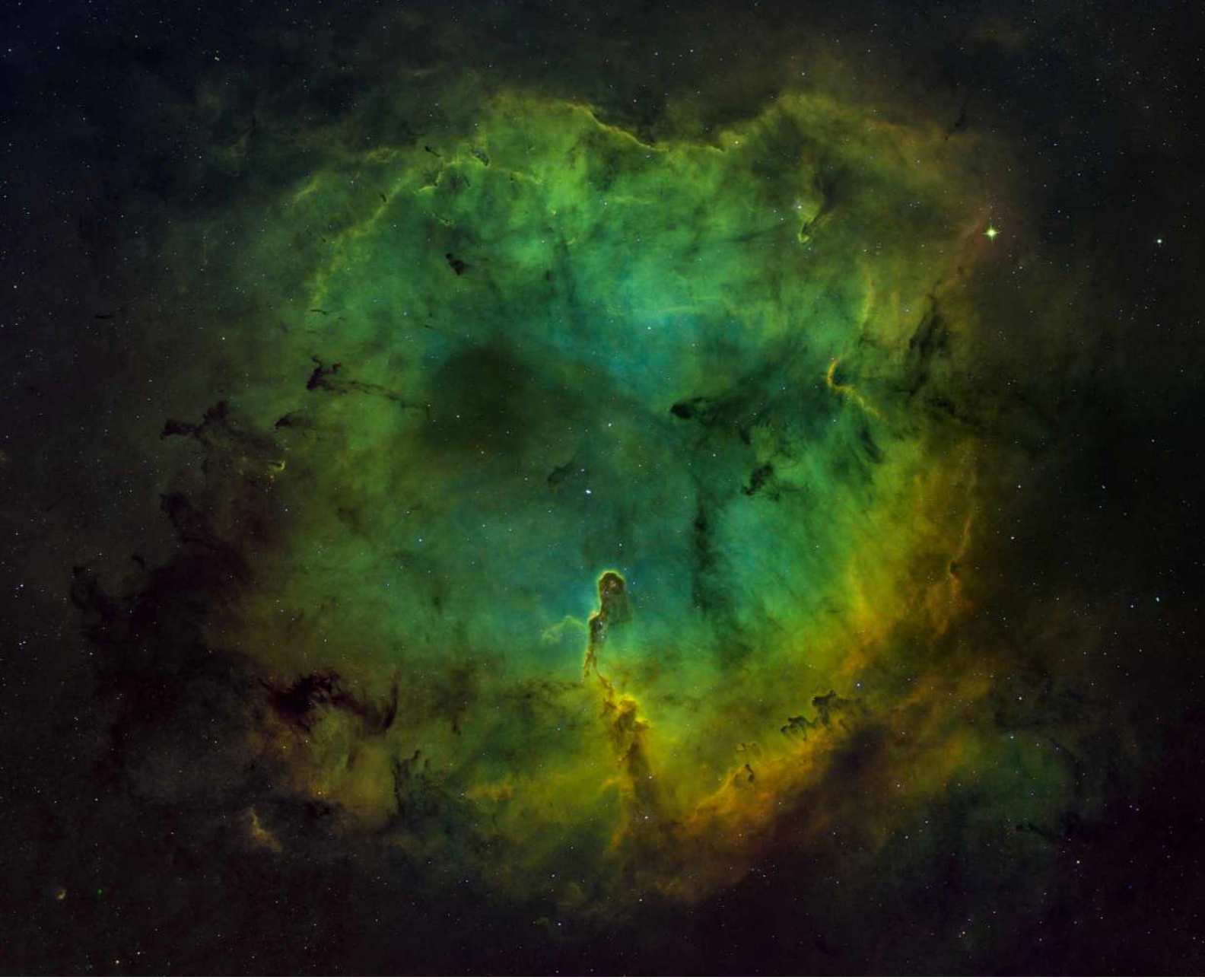
Equipment: Nikon D5300 DSLR, William Optics RedCat 51 refractor, iOptron SkyGuider Pro mount; Nikon D5600 DSLR, William Optics RedCat 51 refractor, iOptron SmartEQ Pro mount **Exposure:** 60x 60", 100x 30" **Software:** DeepSkyStacker, PixInsight, Photoshop

△ Polar-ring galaxy NGC 660

Martina McGovern, near Cambridge, 3 September–1 November 2021

Martina says: "This is my most challenging project so far, requiring over 20 hours of data over six nights."

Equipment: ZWO ASI294MC Pro camera, Celestron 8-inch EdgeHD Schmidt Cassegrain, Sky-Watcher HEQ5 Pro mount **Exposure:** 20h total **Software:** DeepSkyStacker, PixInsight, Photoshop



△ The Elephant's Trunk Nebula

Martin Cohen, Fareham, Hampshire, October–November 2021

Martin says: "Going for both detail and a wide field of view demanded a 3x3 mosaic. To achieve this I had to acquire 27 hours of data over four nights."

Equipment: ZWO ASI2600MM Pro camera, Sky-Watcher Quattro 8CF Newtonian, Sky-Watcher HEQ5 mount **Exposure:** 9 panels, 15–20x 180" per channel **Software:** DeepSkyStacker, Photoshop, Starnet++

◁ Mineral Moon and Moon

Fernando Oliveira de Menezes, São Paulo, Brazil, 7 November 2021

Fernando says: "I recorded the mineral Moon (left) in RAW format and the other in mono, adjusting the saturation of the RAW image to bring out the mineral details."

Equipment: ZWO ASI6200MC camera, Sky-Watcher Esprit 150ED refractor, iOptron CEM70 mount **Exposure:** 900x 0.15" **Software:** AutoStakkert!, RegiStax, Photoshop

△ The Phantom Galaxy

Rob Johnson, Liverpool, 26 September, 30 October and 3 November 2021

Rob says: "M74 is a difficult target to observe from my Bortle 7–8 skies due to its low surface brightness, but I can't resist face-on spiral galaxies so I gave it a go."

Equipment: Atik 383L+ camera, TS-Optics ONTC 12-inch Newtonian, Sky-Watcher EQ8 mount **Exposure:** 7.8h total **Software:** PixInsight

△ The Lobster Claw Nebula

Ron Brecher, Guelph, Ontario, Canada, 25 November 2021

Ron says: "Using the Hubble Palette reveals some of the chemistry of this dynamic region of space."

Equipment: QHYCCD QHY600M camera, Sky-Watcher Esprit 150ED refractor, Paramount MX mount **Exposure:** Ha 22x 20', OIII 22x 20', SII 22x 20' **Software:** PixInsight

◁ Comet Leonard

Tom Masterson and Terry Hancock, Grand Mesa Observatory, Colorado, USA, 25 November 2021

Tom and Terry say: "This captures Comet C/2021 A1 Leonard as it passes the Whale and the Hockey Stick Galaxies."

Equipment: QHYCCD QHY367C camera, Takahashi E-180 astrograph, Paramount GT1100S mount **Exposure:** 116x 60" **Software:** DeepSkyStacker, PixInsight, Photoshop

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90

Unistellar's new 'smart' telescope, the eVscope 2, sports an upgraded eyepiece. We tested it on a range of deep-sky targets

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books on the Russian Space Race and a starter guide to the cosmos, plus a roundup of must-have astronomy gear

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FIRST LIGHT

SharpStar SCA260 Aspherical Cassegrain Astrograph telescope

A large aperture instrument, tailored for deep-sky astrophotography

WORDS: TIM JARDINE

VITAL STATS

- Price £3,590
- Optics Corrected Aspherical Cassegrain
- Aperture 260mm
- Focal length 1,300mm, f/5
- Focuser 3-inch rack and pinion
- Tube material Carbon fibre
- Weight 15kg
- Supplier First Light Optics
- Email questions@firstlightoptics.com
- www.firstlightoptics.com

We always welcome the chance to review something a bit different and the new SharpStar SCA260 piqued our interest, not only because of the unusual aspherical Cassegrain optical design, but also because of the attractive price tag for such a large telescope.

The SCA260 certainly is large – at over 700mm long and 280mm wide, the telescope is geared towards experienced astrophotographers – so we opted for a permanent pier-mounting option. Even with its lightweight and stylish carbon fibre housing it still tips the scales at around 15kg, and that is before we added our cameras and guiding equipment. Much of the weight comes from the large aspherical mirror and the secondary mirror and its housing, which is typical of Cassegrain designs where the focal point lies behind the primary mirror.

With the telescope safely mounted and balanced, we looked at the collimation of the secondary and primary mirrors, which both needed adjusting. At first, we attempted this with the tube in a convenient horizontal position at night, but found it was much easier to complete the alignment process in daylight. There is a basic, printed four-step guide provided, which mentions 'Catseye collimation' and we took this as a reference to a Catseye Cheshire Eyepiece (available separately), which we happened to have on hand.

Minor adjustments

The secondary mirror is the first to be adjusted, then the primary – in both cases using the provided Allen keys to centre the reflections in the eyepiece. The primary mirror is held steady by no less than nine supporting thumbscrews, which makes the anodised red rear section of the telescope look quite busy. When we started using the SharpStar SCA260 we noticed that the considerable weight of the secondary mirror holder was causing a small amount of movement of the mirror on the spider vanes, which was throwing the collimation out when the telescope was slewing, but after a little experimentation we solved this issue by aligning the mirrors, pointing the SCA260 roughly at Polaris (Alpha (α) Ursae Minoris), the North Star, to do this.

The optical arrangement of the telescope makes it ▸

ALL PICTURES: @THESHED/PHOTOSTUDIO

Focuser

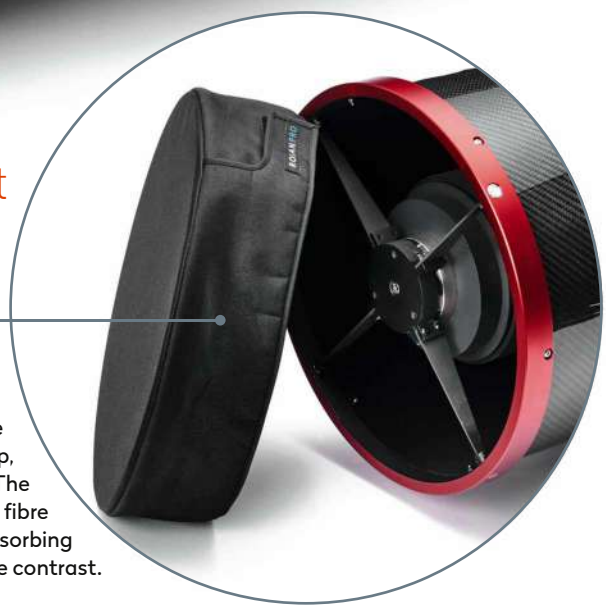
The 3-inch rack and pinion focuser with a graduated drawtube has a dual speed, 1:10 gearing for fine focusing. It offers the choice of either an M54 x 0.75mm or M48 x 0.75mm male thread at the rear, which allows for a solid and square attachment of camera equipment.

CNC-machined tube rings and dovetails

The stylish red anodised tube rings are made from a single piece of aluminium and they are permanently attached as supports for the carbon fibre tube. The top handle and Losmandy-style dovetail plate are precisely CNC-machined and securely fitted, ensuring a rigid and strong assembly.

Lightweight end cap and tube locking

The dust cover or end cap of the tube is made from tough fabric with a lightweight insert, and fastens snugly around the tube via a Velcro-style strap, which holds it securely in place. The internal surfaces of the carbon fibre tube are flocked with light-absorbing material to enhance contrast.



FIRST LIGHT

Hygrothermograph

A battery-operated, digital hygrothermograph is fitted to the rear of the telescope, allowing the operator to monitor outside temperature and relative humidity. Although slightly gimmicky, the unit may alert you to especially damp nights when excess dew might cause an issue with this type of open-ended telescope.

Built-in fans

The rear housing behind the primary mirror has three mounted fans that operate from a 12V DC power supply. These fans pull in air at ambient temperature, blow it over the rear of the primary mirror, and it exits at the front of the tube, which actively reduces cool-down time.

Corrected aspherical optical system

Although it looks similar to a Schmidt-Cassegrain Telescope, the SCA260 Aspherical Cassegrain Astrograph (ACA) uses a different optical arrangement to produce an image. When light enters the open-ended tube it encounters the 260mm aspherical primary mirror with its central hole. This light is then reflected back up towards the large 120mm spherical secondary mirror which, in turn, directs the light path through the central hole in the primary mirror. At this point the light travels through a three-layered image correcting lens, which helps to flatten the image.

This three-tiered approach allows the SCA260 ACA to operate a large aperture at a 1,300mm focal length, with a useful f/5 focal ratio, putting this type of scope in a class of its own. The unobstructed image circle through the 3-inch focuser is 80mm, which more than covers a full-frame camera without vignetting issues. The primary mirror is made from low expansion PZ33 glass for thermal stability, and both mirrors are coated with aluminium. A reflectivity greater than 95 per cent is quoted.

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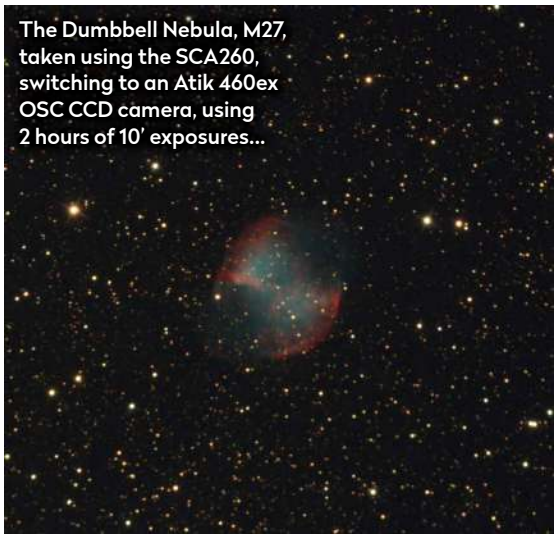
◂ The Pleiades, M45, taken with an Altair 24CFX full-frame OSC camera and the SharpStar SCA260, using 2 hours of 10' exposures



The Dumbbell Nebula, M27, taken using the SCA260, switching to an Atik 460ex OSC CCD camera, using 2 hours of 10' exposures...

▲ ...and spiral galaxy NGC 891, taken with the same setup using 5 hours of 10' exposures

▸ suitable for a wide range of astronomy cameras. We chose two for our review, a full-frame colour CMOS camera and a smaller sensor colour CCD camera. Between them these cameras enabled us to explore the limits of the wide image circle the SCA260 is capable of, and the sharpness and quality of the image when used on smaller targets, such as galaxies.

There are no requirements for the specific spacing of the camera – as long as the image is in focus the spacing is correct. With 75mm of back focus to play with there is plenty of room for filter wheels or off-axis guiders.

Tweaking the focuser

The focuser itself was smooth and easy to operate and it held well, even without being locked. However, we did find that there was some unwanted movement of the drawtube that got worse with more extension. We didn't find any negative effects on the images we took, but it is worth being aware of this and maybe tweaking the focuser.

When we tested the SCA260 with the full-frame colour CMOS camera, it allowed us to capture large targets like the Pleiades, M45, in their entirety, with sharp refraction spikes on the brightest stars. Towards the edges and corners of the image the star shapes became a little elongated as expected, and were consistent with the results of the spot diagrams available on the supplier's website. With our smaller sensor camera the results were really pleasing too, especially on photogenic galaxies like NGC 891, and we were able to capture the kind of images that first got us interested in astrophotography. Meanwhile, smaller deep-sky objects – like the Cigar Galaxy (M82), the Dumbbell Nebula (M27), the reflection nebula M78, and the bright star cloud NGC 206 within the Andromeda Galaxy – presented a relatively close-up field of view and good detail.

Minor niggles aside, we were quite excited by the SCA260. With its large aperture, fast focal ratio, medium-long focal length, and affordable price tag, SharpStar has produced an innovative design. This is a telescope for the dedicated enthusiast.

VERDICT

Build & design	★★★★☆
Ease of use	★★★½☆
Features	★★★★☆
Imaging quality	★★★★☆
Optics	★★★★½
OVERALL	★★★★☆

KIT TO ADD

1. ZWO EAF (Electronic Auto Focuser)

2. OCAL electronic collimator

3. 12V power supply for the integrated cooling fans

FIRST LIGHT

Unistellar eVscope 2 telescope

A 'smart' digital telescope with an improved Nikon eyepiece and greater field of view

WORDS: JAMIE CARTER

VITAL STATS

- **Price** £3,399 (plus £59 for shipping)
- **Optics** 114mm (4.5-inch) reflector
- **Focal length** 450mm, f/4
- **Sensor** Sony Exmor IMX347 CMOS
- **Mount** Motorised single-arm, altaz, Go-To
- **Power** Built-in, lithium-ion rechargeable (12-hr) battery
- **Tripod** Aluminium, adjustable height
- **Ports** USB-C for power, and USB-A for charging a smartphone
- **App control** Unistellar app for smartphones
- **Weight** 9kg
- **Supplier** Unistellar SAS
- **Email** contact@unistellaroptics.com
- **https://** unistellaroptics.com

Take a look through the electronic eyepiece on the side of the Unistellar eVscope 2 'smart' digital telescope and you will notice a major upgrade from the original eVscope. The new Nikon-made eyepiece on the eVscope 2 creates real-time views of deep-sky objects that are both blacker and more colourful than before.

A new eyepiece isn't all that has changed in the second version of Unistellar's flagship telescope. The eVscope 2 is fitted with a new Sony camera sensor and continually tracks-and-stacks images in real-time to produce colourful views of deep-sky objects, both at the eyepiece and via an app.

Another notable improvement is the eVscope 2's wider field of view, which has been increased from 30 arcminutes to 34 arcminutes. This means that it is now possible to see more of large objects, such as the Andromeda Galaxy, M31, and, crucially, the Moon. The eVscope 2 is at its best under a dark sky; take it away to dark rural skies (something you can easily do using its excellent backpack) and it's possible to take images of objects as faint as 18th magnitude. However, if you use it in the centre of a city, it can still see down to around 16th magnitude without the need for any filters.

Simple set up

Like its stablemates, the original eVscope and the eyepiece-less eVscope eQuinox, the eVscope 2 works differently to the average telescope. A 4.5-inch reflector telescope with a motorised altazimuth mount, it flirts so heavily with Nikon and Sony that it's as much a basic astrophotography rig as a telescope. That eyepiece and sensor aside, the eVscope 2 is simple to set up, by lifting the all-in-one tube and motor (with the computer and battery) onto a hefty tripod, which is fitted with a spirit level. Once it is in position, all the user needs to do is switch it on, attach a phone or tablet to its Wi-Fi network and begin a short set-up process. A press of a button on the Unistellar app engages the 'Automatic Field Detection' mode to calibrate its database. It's also sometimes necessary to collimate or focus the eVscope 2 by using the Bahtinov mask hidden in its dust cap; the manufacturer's YouTube videos are very helpful in this respect.

Once set up is complete, it's possible to slew ▸

▸ The eVscope 2 comes with a purpose-made hiking backpack

@THESHED/PHOTOSTUDIO X 4, JAMIE CARTER

Optics and view

The design incorporates a 114mm (4.5-inch) diameter mirror with a 450mm (17.7-inch) focal length, which gives a focal ratio of f/4. A field of view of 34 arcminutes allows full-screen photography of the Moon, which wasn't possible with the original eVscope's field of view of 30 arcminutes.

Enhanced Vision

Light is focused directly onto the new Sony Exmor IMX347 CMOS sensor located inside the spider vane on the front end. In 'Enhanced Vision' mode the onboard computer images an object every four seconds and stacks the results as a 7.7MP composite image.

Tripod

Included in the package is a large and sturdy tripod that goes beyond what you might expect to use with a camera. When it is extended, its legs have three sections, with the joins held together by flip-locks. At the top is a hole that the telescope tube slots into, with two small screws securing it in place.

FIRST LIGHT

Focusing wheel

To get sharp stars, it's first necessary to point the eVscope 2 at a starry target. Next, extract the Bahtinov mask from inside the dust cap and click it into place on the front of the tube. It's then possible to manually adjust the focusing wheel on the bottom of the tube to align the Bahtinov mask's three starlight spikes.

Mount

The L-shaped altazimuth mount contains the motor, which moves the telescope into position and then accurately tracks objects. Inside is a lithium-ion battery (recharged via a USB-C slot on the bottom) and the onboard computer with 64GB storage. A USB-A slot on the side can recharge a smartphone or tablet.

An upgraded eyepiece

The eVscope 2 features an all-new electronic eyepiece developed by Nikon. There are three reasons why it's impressive; the first is that it's used for focusing the telescope, one of the few tasks that isn't automated. To achieve a sharp focus, it's necessary to use the Bahtinov mask that's included and to manually tweak the focusing wheel at the bottom of the tube close to the eyepiece. So, while it's possible to rely on seeing sharp images via the Unistellar app, it's much quicker and easier to just put your eye to the eyepiece.

The second reason why the new eyepiece is a step forward is image quality. Its micro-OLED (Organic Light-Emitting Diode) display has a high-pixel density that shows a sharp image with contrast that manages true black and more vibrant colour. The eyepiece gives the eVscope 2's images more depth, making the view more convincing and involving when in use. Thirdly, there's more to look at than before through the eVscope 2's eyepiece, thanks to its wider field of view that can now encompass the whole of the Moon.

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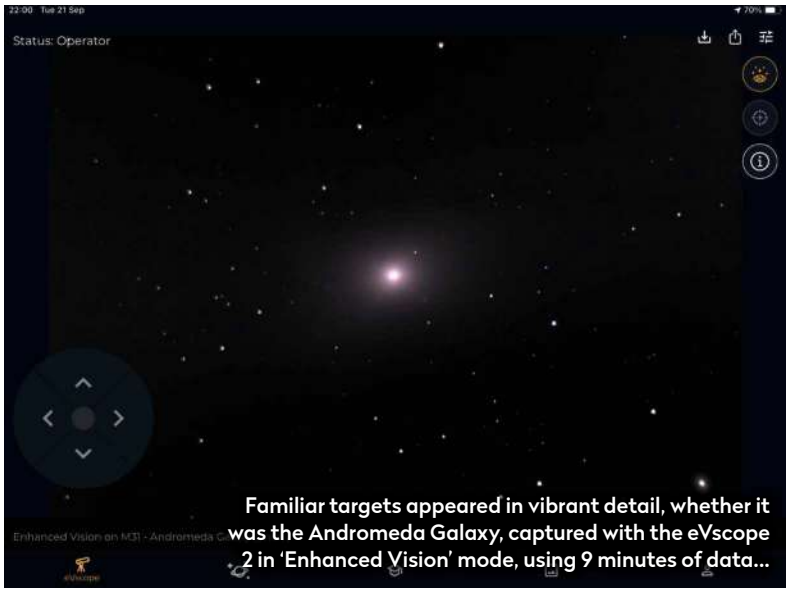


Familiar targets appeared in vibrant detail, whether it was the Andromeda Galaxy, captured with the eVscope 2 in 'Enhanced Vision' mode, using 9 minutes of data...

▲ ...or the Orion Nebula, captured using 21 minutes of data captured and stacked automatically

The eVscope 2 brought out bright detail in the stars of the Pleiades, M45 – with Alcyone (Eta (η) Tauri and Merope (23 Tauri) on view...

▲ ... and it captured Uranus and three of its moons (Titania, Oberon and Umbriel) plus the faint star Ariel, hidden in the top spike to the left of Umbriel

▸ to objects that the Unistellar app recommends. The app is excellent, with plenty of advice on what targets are about to set or rise, or the targets that are in a prime position for observing. With a target in its crosshairs the app then invites the user to engage 'Enhanced Vision' mode. This is where the eVscope 2 does its best work, with its computer imaging an object every four seconds and stacking the results. The longer you let the eVscope 2 image a target, you will be able to see the resulting astrophoto visibly refresh, align and improve. Its 7.7MP images are then visible to anyone close by with the Unistellar app open on a smartphone or tablet. You can also export them as PNG files and share them easily on social media. As it stands at the moment, you can't easily access the RAW image files because the process involves uploading to Unistellar's servers.

Image quality

So, how do the photos measure up, and are they any good? Yes, but you're not likely to win any astrophotography competitions with them. Best seen as an effective way to do and to share astronomy from anywhere – and particularly when under light pollution – the eVscope 2's new sensor produces images that appear to have more detail, contrast and colour vibrancy than on previous models. The transparency of the sky makes a huge difference too, but over several clear nights of observing we were able to get fabulously colourful images of the Orion Nebula, M42, watching in awe as each new image was intelligently aligned to reveal more detail. The image settings for each object are automatic, but you can make manual tweaks to the gain, exposure and brightness.

This expensive digital telescope is the ultimate anti-light pollution solution. It's not going to replace high-end astrophotography rigs, and it may be on the expensive side for many amateur astronomers, but as a piece of new consumer technology it's hugely impressive. It could well be the future answer for urban astronomy.

VERDICT

Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★½
Go-To/Tracking accuracy	★★★★★
Imaging quality	★★★★½
OVERALL	★★★★½

KIT TO ADD

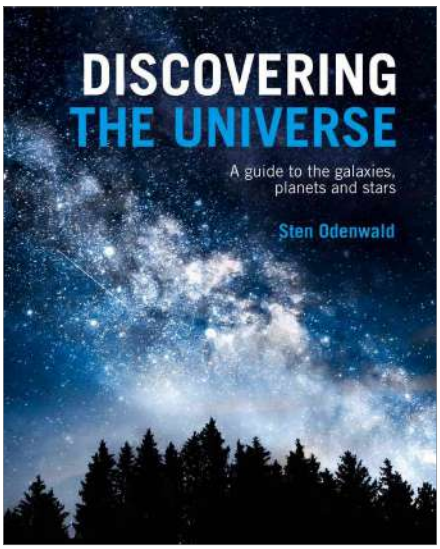
1. A portable battery

2. Extra-long USB-C cable

3. The Instagram app, to show off your images

New astronomy and space titles reviewed

BOOKS



Discovering the Universe

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£14.99 ● HB

Discovering the Universe is designed to be a book for beginners, providing an introduction to different aspects of the Universe via eight chapters that include 'How to build a Universe', 'Stellar evolution' and 'Planetary systems'. The layout being half text and half pretty pictures makes each chapter digestible and quick to read. The language is more informative than mere storytelling. These aspects would make the book perfect to inspire readers about our Universe, except there are a number of issues that crop up upon reading.

There are several errors in *Discovering the Universe*, some of which might be excused as typos (such as mislabelling the location of the Virgo detector as being in Louisiana rather than Italy and implying that the James Webb Space Telescope launched in October 2021. More importantly is the fact that the book tries to cover too many topics too briefly and without providing the necessary background. This makes certain concepts confusing or misleading. For instance, 'gravity waves', a term that the author uses repeatedly, are something very different to 'gravitational waves'. The few pages on this topic imply that current gravitational wave detections could have come from mergers of compact objects that include a white dwarf, which is not true. If more considered language was used, such misleading information could be avoided. But since this book is meant for beginners, there is a worry that the reader could come away with the wrong ideas. It is also a pity that the author doesn't highlight contributions to astronomy from women, and repeatedly uses language such as 'manned' when describing space exploration.

Discover the Milky Way and much more in this book for beginners

The second half of the book is much more enjoyable than the first. It describes the Milky Way and Solar System, and as such is filled with beautiful images rather than artist's impressions. However, many readers may not be able to put *Discovering the Universe* on the same bookshelf as other beginner astrophysics books that are A4 in size with gorgeous pictures – the books that inspired generations of children and young people when they first began discovering the Universe.

★★☆☆☆

***Laura Nuttall** is a senior lecturer in gravitational waves at the University of Portsmouth*

SOLARSEVEN/ISTOCK/GETTY IMAGES

Interview with the author
Dr Sten Odenwald

How old is astronomy?

The best evidence we have that our distant ancestors paid attention to the night sky comes from preserved objects such as the Nebra sky disc (c. 1,600 BC) and alignments in Stonehenge (c. 3,000 BC), and it could also include alignments in Göbekli Tepe in Turkey (c. 9,000 BC). Some controversial evidence also includes cave art from 40,000 BC. We are not that different to our Paleolithic ancestors and we all enjoy looking at the night sky. We have probably done so for 100,000 years!

Are we any closer to discovering why anything exists?

Compared to 100 years ago, we have arrived at an answer in terms of the origin of planets, stars and galaxies. But Big Bang theory and the Standard Model are now begging questions for which experimental verification seems beyond reach. Our best attempts to extend these theories do not tell us why time or space exist at all. We also have no idea how consciousness and the human mind evolved from inanimate matter.

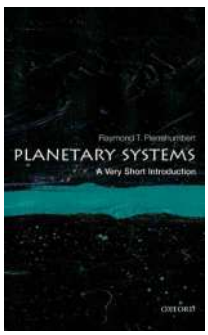
What are your hopes for the future of crewed spaceflight?

I hope in the next 100 years we will invest in nuclear-electric propulsion engines (that we already know how to create), so we can take trips to Mars in under a few weeks. This reduces the risk of radiation poisoning and biological decay that currently plagues long-term occupation of space. We will have colonies on the Moon and Mars. We will have robotic AI-driven probes crawling around on the surfaces and oceans of Europa and Titan. We may even find life!

***Sten Odenwald** is Director of the STEM Resource Development project at NASA and a science educator*

Planetary Systems: A Very Short Introduction

Raymond T Pierrehumbert
Oxford University Press
£8.99 ● PB



Don't be fooled by the title: this book might be short, but it provides an expert, comprehensive overview rather than a brief introduction.

The 'Very Short Introduction' series is designed to give a succinct, accessible introduction to a particular topic written by a variety of experts on their specialist subject, yet in a slim format that could easily fit in a pocket. The *Planetary Systems* of the title covers both our own Solar System and those across the Universe, and discusses their formation and evolution, the methods and missions through which astronomers have learnt about them and how life might develop in these distant systems in snappy chapters.

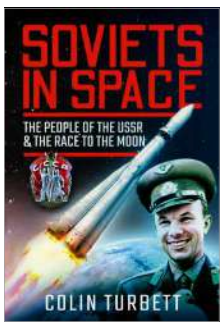
This is not necessarily an introduction for total beginners – some familiarity with common physics concepts would be useful to get the most out of it – but it is clear and concise. The writing is not especially floral or embellished, but that's the point: it is efficient and articulate, and it tells you what you need to know. The author manages to sprint through the material at an impressive rate without sacrificing knowledge or becoming unclear. Diagrams are used effectively to illustrate ideas and a useful list of further reading is included. Brief histories of important telescopes like ALMA and key figures such as Emanuel Swedenborg are also included, giving a context to the technical content.

For those wanting to learn about planetary systems, there could be no better starting point. ★★★★★

***Katie Sawers** is a science writer specialising in cosmology and the history of astronomy*

Soviets In Space

Colin Turbett
Pen & Sword
£25 ● HB



The story of the Space Race between the competing ideologies of the US and the Soviet Union has, until recently, been rather one-sided. While the triumphs and failures of the US took place under the gaze of publicity, the Soviet approach was different.

Rather than concentrating on the technical details, this book primarily tells the stories of people; from ordinary citizens inspired by the advances made by their nation, to those most closely involved in this highly secretive world.

Soviets in Space begins by looking at the USSR, following the devastation of World War Two and how they built on the knowledge developed by Germany to create their own missile and rocket programmes. We are taken on a journey from the first flights, with their early successes and milestones, right through to the collapse of the Soviet Union.

The author does a great job in cutting through the propaganda and bias that coloured both sides' opinion of their rival and details both the triumphs that we heard about and the failures that were kept hidden. Some of those brave pioneers have only been publicly acknowledged since the end of the Cold War.

Some readers may be disappointed by the lack of technical details regarding the launchers and vehicles, but the book lives up to its subtitle, "The people of the USSR and the race to the Moon".

We are reminded that, despite the political tensions, those involved on either side were gifted and brave. ★★★★☆

***Mark Bowyer** is a science writer and an expert in the US crewed space programme*

This Way to the Universe

Michael Dine
Viking
£20 ● HB

KEY SCIENCE

The two flagship theories of modern physics, general relativity and quantum mechanics, are staggeringly successful in their description of the Universe. But, frustratingly, science is still far from an all-encompassing 'theory of everything'. This first foray into popularisation from physicist Michael Dine seeks to show how we have arrived at the current impasse, while extolling the many puzzles and triumphs along the way.

After discussing the emergence and development of the two principal theories, the author leads us through contemporary areas of research such as quantum chromodynamics, supersymmetry and string theory. Although primarily concerned with the very small, the implications of particle physics for cosmology, cosmic inflation, the Hubble Constant, dark matter, dark energy, the fate of the Universe, the existence of multiverses and more, are expertly laid bare.

It is not an easy task to take the complexities of theoretical physics, which is deeply ingrained in advanced, sometimes even esoteric mathematics, and translate it into common prose. It is even more difficult to make that prose accessible to the lay enthusiast. The author has done an admirable job and hasn't shirked away from many of the more difficult and arcane topics, but the reader should be in no doubt that the text is heavy going. This is a book about mathematics, with no mathematics, and one should expect some confusion, re-reading of sections, even a healthy mental bruising, before the last page is turned. But as a comprehensive and uncompromising tour de force of literally all of fundamental physics, there can be few better alternatives. ★★★★★

***Dr Alastair Gunn** is a radio astronomer at Jodrell Bank Observatory in Cheshire*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Astronomy Fluxx

Price £11.99 • **Supplier** Travelling Man • **https://travellingman.com**

A space-based card game where the rules are always changing. The cards feature NASA photos of planets, nebulae and galaxies, and a range of space facts. The game is simple enough to play with the whole family, so you can all learn about the cosmos together.

2 Powapacs Atom Pro

Price £239 • **Supplier** First Light Optics • **www.firstlightoptics com**

Getting away from civilisation is a great way to avoid light pollution, but it can be harder to keep your setup powered. This high capacity power station weighs just 2kg, but it can run devices up to 150W. It can connect to a solar panel (sold separately) to charge in the day.

3 Orion 0.8x Reducer- attener

Price £212.99 • **Supplier** Orion • **https://uk.telescope.com**

ADVANCED

Get sharp stars to the edge of your image field with this reducer-flattener. It minimises curvature while reducing the effective focal length of your system to ensure a wider field of view and shorter exposure times. Available in 115mm and 130mm sizes.

4 Baader Zenith Prism Diagonal

Price £110 • **Supplier** Widescreen Centre • **Tel** 01353 776199 • **www.widescreen-centre.co.uk**

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Ezzy Pearson interviews Mark Clampin

Q&A ABOUT THE SCIENCE OF THE JWST

At the end of December, the James Webb Space Telescope began its mission to explore the cosmos, but what does it hope to achieve?

What is the James Webb Space Telescope (JWST)?
It's a 6.5m-aperture infrared telescope, which means it is looking at heat radiation. We have used gold to coat the mirror, which is extremely reflective in infrared wavelengths, so we collect something like 97–98 per cent of all the light that hits the telescope.

How have you fitted a 6.5m-wide telescope in an Ariane 5 rocket, which is only 5m wide?
The size of JWST's mirror presents a lot of interesting challenges. We've made the mirror out of 18 individual, hexagonal segments and have folded everything up for launch, so the central part of the mirror is in 12 segments, with three on each side which we have actually folded around the side of the telescope for launch. Then, once it's in space, we can deploy it.

Are there any other challenges to building such a big infrared space telescope?
The problem with observing in the infrared region of the electromagnetic spectrum is that you need your telescope to be cold enough so that it's not just seeing its own heat signature. For the science that we want to do, we actually have to have the JWST as cool as 40 Kelvin, equivalent to 40 degrees above absolute zero. The approach that we've taken is something called 'passive cooling'. The idea is that you fly the telescope with a large, tennis court-sized array of membranes that act as a sunshield, so the telescope cools down to the temperature that we want to operate at. Then, on the other side of those membranes, we've got the spacecraft bus (its main structural body) and all the parts that we need to be looking at the sunlight.

Where is the JWST going?
It is going to the second Lagrange point (L2), which is a sort of quasi-gravitationally stable location about 1.5 million kilometres from Earth. We've selected somewhere that's always in the Sun as we need power for the solar arrays, which can operate at L2 for 24 hours a day, seven days a week. It's also a thermally benign environment out there. As Hubble goes around Earth its focus changes slightly as it goes from day to night to day, something like five microns. You can't see that in Hubble's data, but if you tried to do that with JWST's big mirror, you would see the image quality change. At L2 it will be much more stable.

ESA-MANUEL PEDOUSSAUT

▲ **On 18 December, the JWST was successfully placed inside the Ariane 5 rocket ahead of it launch**

Mark Clampin is the Director of Sciences and Exploration at NASA's Goddard Space Flight Center

What science will the JWST do?
It's an observatory, and can look at a number of different science themes. The original science team that drove the creation of the JWST wanted to look at the very first stars and galaxies in the Universe. We think the first stars and galaxies formed 100 million to 300 million years after the Big Bang. The challenge for us arises because the light from those stars has been shifted so far into the red that they're actually in the infrared. Then in our own Galaxy we want to study how stars form and evolve. Hubble took beautiful pictures of the big, dark dust clouds, but with the JWST we want to look inside these stellar nurseries and see the stars as they are forming. The final theme that we are excited about is examining exoplanets. We've started studying the atmospheres of some of the big gassy planets, but with JWST we'll start to look at super-Earths and potentially some Earth-like planets. We'll want to begin looking at their atmospheres and compositions.

How did you decide what to observe?
The first year has been divided up into observations that will be conducted by the teams who built the instruments. Then there's a set of observations that have been planned for the science community to get an early look at JWST data and understand the telescope's performance and what it can do scientifically. There's also a whole set of proposals that were awarded time based on their merit. There is plenty of interest in studying early galaxies for the first time and I think, ultimately, that will be JWST's legacy.

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Follow the trail of Hydra, the Snake, catch three comets in the night sky and visit Castor in Gemini

When to use this chart

1 Feb at 00:00 AEDT (13:00 UT)
15 Feb at 23:00 AEDT (12:00 UT)
28 Feb at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

FEBRUARY HIGHLIGHTS

The evening sky is home to three comets which have past their perihelia and are near maximum brightness. First is 19P/Borrelly, the most luminous, around 8th magnitude, in Aries, the Ram, which sets an hour after twilight. Setting two hours after Borrelly is 104P/Kowal 2, around 10th magnitude, which moves from Cetus, the Whale into Taurus, the Bull mid-month. Next is 10th magnitude C/2019 L3 (ATLAS) in Gemini, the Twins, which sets early morning.

STARS AND CONSTELLATIONS

Hydra, the Snake now meanders its way across the northern evening sky. Considering it's the largest constellation by area, Hydra is also one of the faintest and difficult to recognise, except for its head. This faint asterism is comprised of six 3rd and 4th magnitude stars in a squashed semicircle. Being in a barren part of the sky it's visible to the unaided eye under dark skies or fills the field of low power binoculars (5°). The head is 15° east of Procyon (Alpha (α) Canis Minoris).

THE PLANETS

With Jupiter and Neptune vanishing into the western twilight, the evening sky remains Uranus's domain (leaving at 22:00). The sky is devoid of planets until Mars arrives about 03:00, which is followed by Venus, which reaches maximum brightness at mag. –4.9 mid-month. (These planets travel together for the next couple of months). Mercury is next, appearing before dawn for its best morning return for 2022. Saturn rises from the dawn glow joining it at February's end.

DEEP-SKY OBJECTS

This month we visit Gemini, the Twins, starting with Castor (Alpha (α) Geminorum) (RA 7h 34.6m, dec. +31° 53'). This 1st magnitude star is a wide multiple star system, but I'll concentrate on its two brightest binary members, which have a 440 year-orbit. These mag. +1.9 and +2.9 components are separated by just 5.5 arcseconds, which is not as close as their last periastron passage, when they were just 2 arcseconds apart in the 1960s.

Next, we travel 12° southwest of Castor to discover the open star cluster NGC 2266 (RA 6h 43.3m, dec. +26° 58'). This 9th magnitude concentrated group, which is around 5 arcminutes across, is shaped like an equilateral triangle. A mag. +8.9 star, making its south-southwest corner, dominates this cluster of around 60 sparkling (9th to 13th magnitude) targets. Look for some curving lines of stars!

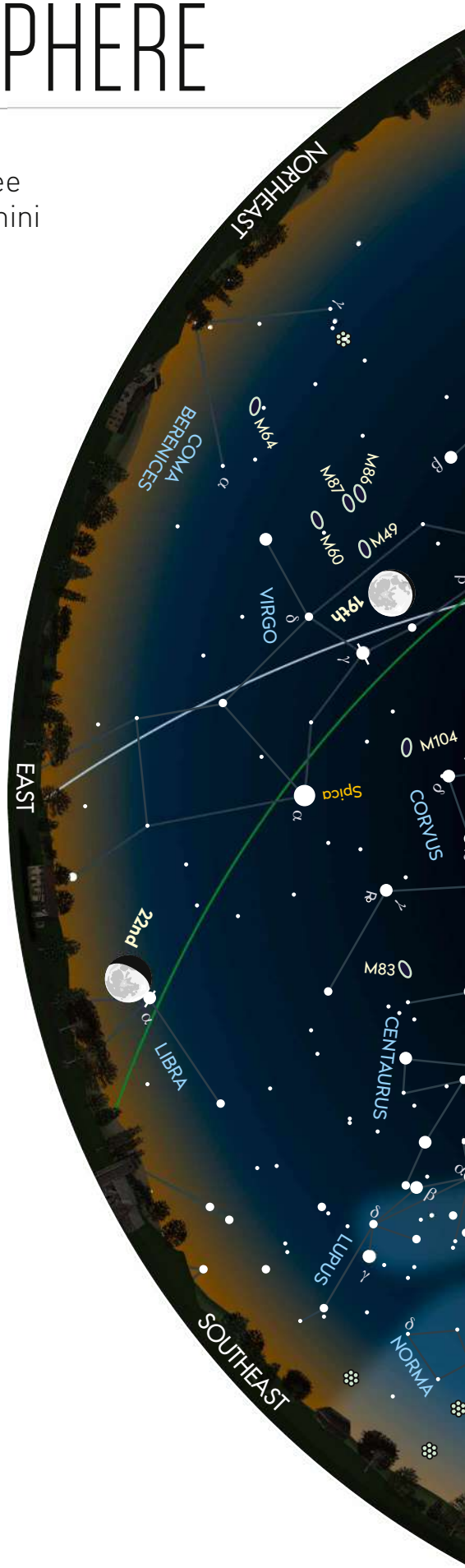
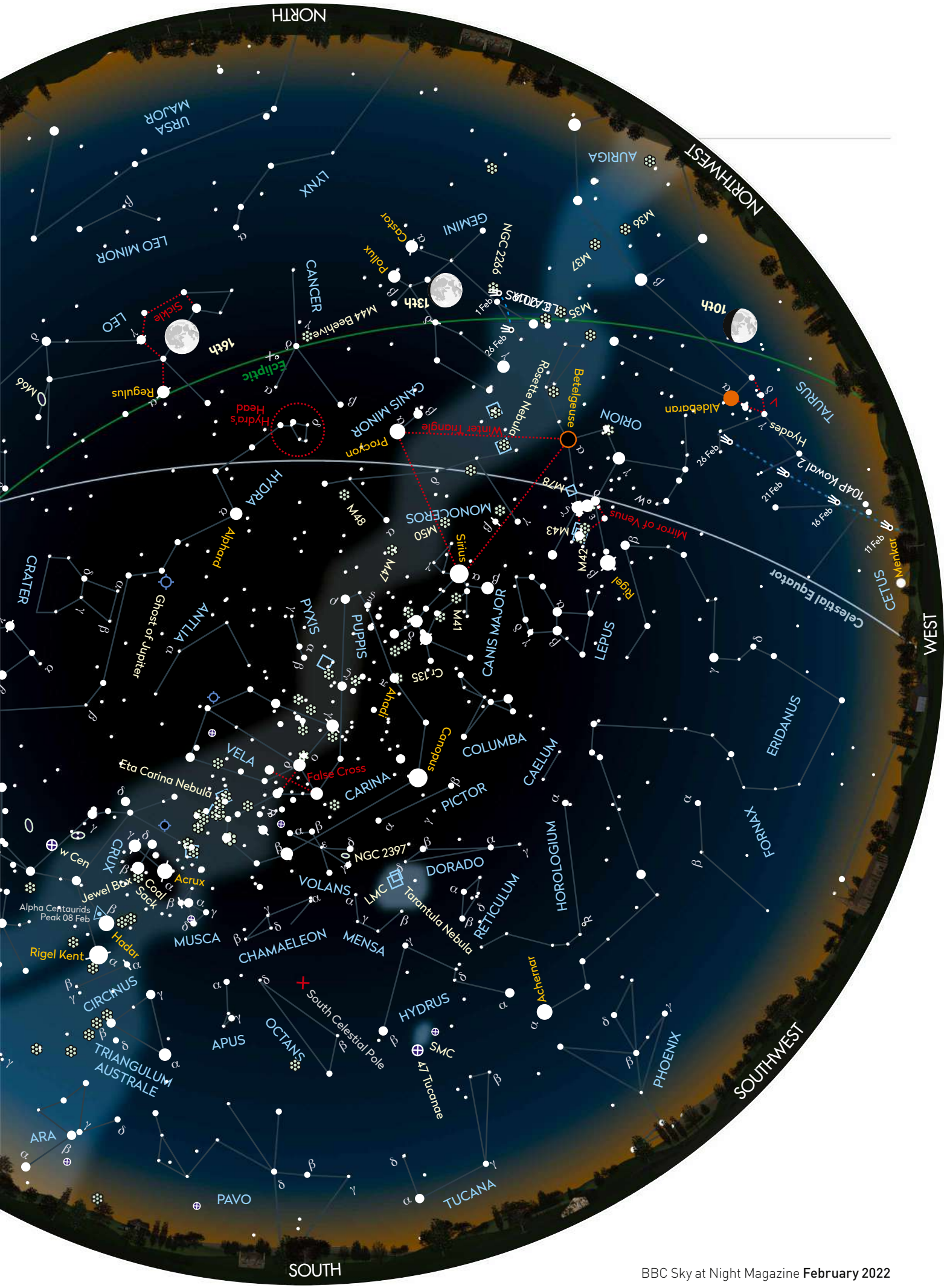


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
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SOUTH
URSA MAJOR
LYNX
LEO MINOR
AURIGA
M36
M37
NGC 2264
GEMINI
Castor
Pollux
CANCER
13th
1 Feb
M35
NGC 2158
26 Feb
10th
LEO
Sickle
16th
M44 Beehive
Ecliptic
M66
Regulus
Hydra's Head
CANIS MINOR
Procyon
Winter Triangle
Rosette Nebula
Betelgeuse
ORION
Aldebaran
TAURUS
Hyades
10Ap Kowal 2
21 Feb
16 Feb
11 Feb
Menkar
CETUS
HYDRA
M48
M50
MONOCEROS
Alphard
M47
Sirius
M78
M43
M42
Mirror of Venus
Rigel
Celestial Equator
CRATER
ANTLIA
Ghost of Jupiter
PYXIS
PUPPIS
M41
C 135
Ahadi
CANIS MAJOR
LEPUS
ERIDANUS
VELA
Eta Carina Nebula
False Cross
Canopus
COLUMBA
CAELUM
CARINA
PICTOR
FORNAX
w Cen
CRUX
Acrux
Jewel Box
Coal Sack
Alpha Centaurids Peak 08 Feb
NGC 2397
VOLANS
LMC
DORADO
Tarantula Nebula
RETICULUM
HOROLOGIUM
MUSCA
CHAMAELEON
MENSA
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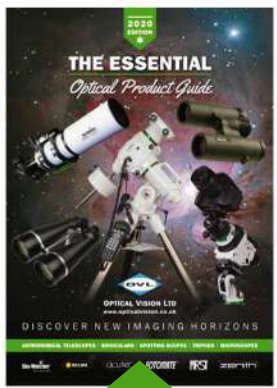

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